THE CONSERVATION OF FRESHWATER FISHERIES IN THE UNITED KINGDOM: AN APPRAISAL OF THE METHODS AND THEIR USES IN THE MANAGEMENT OF NIGERIAN FRESHWATER FISHERIES.

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Summary

The need for an effective conservation and management policy for Nigerian freshwater fisheries has necessitated the study of an advanced situation. The conservation of freshwater fisheries in the United Kingdom, and Scotland in particular, has been used as a blue-print to provide the necessary approach.

The history of conservation and the early approach in the United Kingdom as far back as the 12th century have been reviewed. Social attitude, which is one of the determining forces to freshwater fisheries and their development, is discussed.

The problems and conflicts in the conservation, development and management of freshwater fisheries in the U.K. and the way solutions to these problems have been sought are reviewed. The legislation protecting fish (salmon, trout and freshwater fish) and the environment, and the administrative bodies, particularly those conferred with statutory powers and functions for fisheries are probed considerably.

While appraising the methods in the U.K., for use in the Nigerian field, sight has not been lost of the climatic, biological and social differences and the objectives for the conservation measures between the United Kingdom and Nigeria. The objective of freshwater fisheries conservation in the U.K. is mostly to provide sport and recreation while in Nigeria it is meant to provide food.

Nigerian freshwater fisheries have not developed to a standard to contribute on a high scale to the economy of the nation and the welfare of rural and fishing communities despite her vast and rich inland waters.

For the purpose of improvement to achieve Nigeria's objective, a critique of the United Kingdom methods in freshwater fisheries conservation has been made with the intention to select what would best serve a developing fishery in a developing nation.

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CONTENTS

Chapter I

INTRODUCTION

Fisheries development, particularly in the developing countries, is urgently needed to raise the levels of fish production and consumption. To accomplish this objective, fishery administration and services deserve to be strengthened and improved to embrace a wider range of activities. Effective management and conservation methods should form the framework on which the success of any fisheries rests. With this understanding, I have taken a look into the methods of conservation and management of freshwater fisheries in the United Kingdom for their application, where possible, with a view to injecting improvement and contributing to the management and development of the Nigerian Inland Fisheries.

Nigeria, like any other country, has the policy of developing especially those services which primarily benefit the local population. An important field demanding attention is that of freshwater fisheries. Insufficient steps have been taken to manage and conserve effectively this source of abundant and nutritive food supply. This could be due to the fact that there have been few studies either on freshwater fishes or on the ecology of Nigerian waters.

Nigeria has a vast area of inland waters including the Rivers Niger and Benue, Lakes Chad and Kainji, and the creeks and swamps. At least one million acres (about 405,000 ha.) out of 1.8 million acres (about 729,000 ha.) of swamps in the Niger Delta alone can be readily reclaimed for fisheries development (Pillay, 1973). With such a development the present low fish production from inland waters will improve for the ever increasing population.

Many European countries, including the United Kingdom, have evolved various systems of administering their fisheries. This is done with the purpose of initiating developments, promoting improvements and perhaps acting in an advisory capacity to other countries and international bodies. An exposé of the management and administrative systems of freshwater fisheries, the nature of fisheries problems and ways of solving them in the United Kingdom might be of interest to fisheries personnel of developing countries.

Different countries have different objectives towards freshwater fisheries conservation. In the United Kingdom, with the exception of the Atlantic Salmon and sea trout commercial fishery, the objective is primarily for recreation while in a developing country like Nigeria, it is aimed at fish production for food. With these different objectives, I have tried to align my thoughts to those which might benefit a population that deserve fish for food and not for sport for the time being.

While discussing the problems in the development and conservation of freshwater fisheries in the United Kingdom, more emphasis is on Scotland where much of this work was done and the solutions to these problems some of which, though treated under separate chapters, have also received a similar approach.

Apart from natural events, the activities of man involving water abstraction, pollution, illegal fishing, water resource development, disease and aquatic weed spread due to water impoundment can create problems in fisheries development and management.

Rivers affect and are affected by many aspects of local and national life. Towns have grown beside them and industries have developed on their banks. Regular activities of man involve much use of water. The rivers water the farmlands through which they pass and considerable quantities are abstracted either directly or indirectly for domestic and industrial use. This abstraction lessens the flow in rivers. The prolonged effects of abstraction on salmon rivers, hamper the upstream movement of these migratory fish. The consequences of water abstraction do not only involve a drop in water volume, they also entail changes in physical and chemical qualities of the river system.

Some of the abstracted water is lost to the soil through irrigation, some through evaporation while some is returned to the river never entirely unchanged. This water is either returned heated or less enriched with mineral salts. If this water is passed through sewage disposal works at times, it may return with a load of pollution detrimental to life in river systems.

Pollution can be devastating to life in water. The toxic effluents (cyanides, phenols, sulphides and ammonium salts) produced in coal distillation in England and their effects on fish fauna and water quality are a matter of concern. Fish life is adversely affected by small concentrations (about 2 p.p.m.) of ammonia in alkaline water. The insecticide endrin, has a high toxic effect on fish too.

Heavy metals in solution may cause acute respiratory distress and coagulation film anoxia in fish, while zinc compounds cause histopathological effects of the gut, gills and liver. Thermal pollution, while perhaps favouring eurythermic organisms, can eradicate stenothermic ones. Higher temperatures decrease the tolerance period of organisms, increase the reaction rate of poisons in effluents and cause low dissolved oxygen concentrations. Thermal pollution is known to cause loss of some fish stocks by inducing complete spermatogenesis in Gasterosteus sp. during the non-spawning season.

Changes due to pollution also affect plants. A dominance of green and blue-green algae in a stream may occur due to changes brought about by pollution.

The growth and spread of aquatic plants resulting mostly from reservoir development also give cause for concern. This however tends to be more acute in the tropics than in the temperate region. Their control measures are more of physical method e.g. cutting, burning and hand cleaning. These measures are frequently adopted than the chemical and biological methods of control which demand a greater caution in application.

Exploitation of fish stocks through indiscriminate and illegal methods of fishing constitute a threat to fisheries. It neither allows for good management nor protection for the fish stock and their spawning grounds and it can cause a rapid depletion of fishery resources.

As man's ingenuity has thought up new ways of catching fish, despite their deleterious effects, so too statesmen regulate and ban these new methods in the interest of the resources and the nation. Acts were passed not only to protect the fish but also their spawning grounds and feeding areas.

Environmental protection also became necessary with increased industrialization. Pollution Acts were passed and as the need for legislation arose so too did the need for the administrative machinery to enforce the legislation.

Fishery Boards, River Purification Boards, Regional Water

Authorities, other councils and research bodies created have authority to administer fisheries and other related functions as empowered by the existing Acts. Committees and commissions have also been set up to review the existing laws and make amendments for more effective control.

The positive line of action taken by the United Kingdom to increase and distribute in her waters, varieties of stock of fish, while still conserving her main fisheries is considered.

Fish farms and hatcheries have been established for stock supplementation in rivers and lochs for angling and for the table market. The role of marine and freshwater fish farms not only in stock supplementation but also in world food production has not passed unmentioned. The United Kingdom's problems in fish farming and her contribution to fish production through fish farming are discussed.

In a follow up, a brief account of Nigeria's scope in the development of freshwater fisheries is given. Finally, a critique has been made, of the United Kingdom's system with a view to sifting that which could be applied in the development and management of Nigerian freshwater fisheries.

In order to appreciate the methods involved, a number of field trips were made. In the course of this study, two Regional Water Authorities in England, two Scottish River Purification Boards, Fisheries Research establishments and some other bodies concerned directly or otherwise with fisheries in the United Kingdom were visited. A catalogue of these visits is separately compiled and attached (See appendix). Unfortunately it has not been possible to obtain many statistics on freshwater fisheries in the United Kingdom due to their confidential nature.

Although most research work in freshwater fisheries management to which I refer concerns salmon and trout, I also refer to tropical conditions. This approach will touch on the nature of fish stocks obtainable in Nigeria. I have also made a general approach to fishery management and conservation with a hope that prospective and pragmatic fish farmers and fishery establishments can derive some benefit from my contribution. In this way full advantage would be derived and useful solutions to particular problems might be found.

Lastly, it is hoped that some facts mentioned will be of help in the development, improvement and management of Nigerian freshwater fisheries and serve as a basis for further investigations into the unknown of a developing fishery.

Chapter 2

HISTORY OF CONSERVATION, DEFINITION AND ITS SOCIAL ATTITUDE

In the past man's impact on the world around him was not serious in terms of the ability of the world to support him. If the food supply became depleted locally, he could move a short distance to an undepleted area thus leaving the old area to recover. But as the population grew, together with the presence of domesticated grazing animals, more pressure mounted on the environment. Industrialization helped to increase many fold the pressures on the environment and the consumption of resources. Some cultures and traditions developed patterns of frugality and discouraged wastes, while others exploited resources unwisely thus impoverishing the environment more and more.

As signs of overuse appeared, local scarcities began to develop and man's impact on the environment became noticeable. Man with his level of intelligence started to associate causes with effects when shortages developed. Even though measures were devised to alleviate some of the shortages, taboos and social attitudes on the use of certain things were limiting factors. Certain items were abhorred and unaccepted in accordance to religious, cultural and traditional beliefs. Social attitude backed by class distinction also constituted a barrier to use of certain resources.

Despite the social binding, some patriotic nationalists with revolutionary minds were worried about the exploitation and fast depletion of resources. It was the beginning of a revolution. In the words of Reich (Dasmann, 1974):

> "There is a revolution coming and will not be like the revolutions of the past. It will originate with the individual and with culture

> and it will change the political structure only at its final act. It will not require violence to succeed and it cannot be successfully resisted by violence".

The individuals now aware of the prodigal exploitation, waste of resources and deterioration of the at one time beautiful environment of man, proposed a remedial action - CONSERVATION - which is aimed at preserving man's environment in a condition to fulfill his needs for a healthy and satisfying life.

In a special message to Congress in 1962, the late President John F. Kennedy, (Owen, 1971) interpreted conservation as:

> "The wise use of our natural environment; it is in the final analysis the highest form of national thrift - the prevention of wastes and despoilment while preserving, improving and renewing the quality and usefulness of our resources".

Eggeling, (Mills, 1971) said that conservation basically implies looking after and making the best possible use of something which through suitable management can produce a yield in perpetuity.

From different definitions, conservation can be said to be prevention of waste, protection of life forms, preservation and improvement of man's environment through suitable management to renew the quality of a given resource in order to produce a yield for the present and future needs of man. Natural resources when consumed can ultimately be in short supply or exhausted and resources that are only of value in an unaltered state are conserved by protection and preservation.

The scientific approach to conservation and management, though basically related in different countries, social and national attitudes might differ. No matter the differences, there are some fundamental principles in conservation which these differing attitudes do have in common. These are the distinct role of the government and existence of an individual sense of responsibility. There might also be a multiple use of any given resources in order to ensure the greatest good for the people served over a long run.

The role of the government is often expressed through a legislative approach. Legislation and legislative bodies are set up to preserve, protect and improve valuable natural resources. Just like the Salmon and Freshwater Fisheries Acts of the United Kingdom which are designed to protect salmon and freshwater fish from being taken either on their breeding grounds and during the close season. The spirit of conservation was strong even as far back as the time of David I (1124-1153) of Scotland. Then it was enacted that any dam dyke should have a gap big enough to allow a three-year old swine, well fed, to stand in it.

In 1424 during his first parliament, James I of Scotland enacted:

> "whosoever be convicted of slaughter of salmon in time forbidden by the law shall pay forty shillings for the unlaw and at the third time if he be so convicted of such a trespass, he shall lose his life or pay for it". (Mills, 1971).

Throughout the history of Scottish legislation on protection of salmon, restrictions were once relaxed during the time of James I. In his Ninth Parliament an Act passed, though with regard to existing Acts, allowed for poaching by Scotsmen in England and in those portions of the Border waters in which, though Scottish, the English had an interest. Apart from the power to poach, Scotsmen were not allowed to sell salmon before hand to Englishmen or in England. This shows the strict conservation measures as existed from the early days in Scotland.

The Indians in Alaska employed a device to catch salmon on a large scale. This device involved the barricading of streams with logs from bank to bank for ascending salmon. As the salmon gathered in schools at the base of these barricades, it was only necessary to dip them out and transport them to the nearest cannery. This method, under highly competitive conditions, was lethal to salmon stocks. The effect of this was beginning to be seriously felt when an Act was passed by Congress in 1889 to stop this uncontrolled exploitation. It then became illegal for any dams, barricades and obstructions to be erected on any Alaskan rivers for the purpose of stopping the ascent of salmon to their spawning grounds.

Different countries show interests for certain types of fish either on the grounds of commerce, sport, food or availability within their national boundaries. For example Scotland, England and Wales have regard for Atlantic salmon, sea trout, non-migratory trout and some sea fish e.g. haddock, whiting, cod, lemon sole and herring. The Icelanders are interested in the cod for commerce and food. Norway is interested in the cod, salmon and some other sea fish and Denmark has regard for salmon, many marine species and farms rainbow trout extensively.

The Salmon, which is anadromous, is very much valued and accorded statutory protection more than other stocks of freshwater fish in the United Kingdom. With all the existing protective fisheries Acts in the United Kingdom there is some potential for the establishment of freshwater fisheries for food. However, a social and traditional preference for seafish has caused very little attention comparatively in this direction. In 1963, 338,000 tons of cod and 130,000 tons of haddock were landed in the United Kingdom for consumption as against 1,670 tons of salmon (Cmnd. 2691, H.M.S.O. 1965). Apart from the value of salmon for food, its role in overseas exports and sport fishery should not be overlooked. Because of these, steps are taken to conserve it. Freshwater fisheries are known and appreciated for the sport and recreation they offer, instead of, as a food supply as may obtain in some other countries.

The individual sense of responsibility towards the conservation of common 'property' resources is most desirable. Personal sacrifices go a long way to helping the national effort in the upkeep of her resources just as industrial leaders in the United States of America are accepting the principle that pollution control costs are part of the cost of doing business (Owen, 1971). The problem of conservation and management is therefore not a national issue alone. It requires citizens' efforts to succeed even in the presence of socio-economic difficulties.

At times situations may arise which can generate conflict, and decisions are hard to take. Things which are of benefit through aesthetic or contemplative enjoyment or because they perform some protective functions often present some of the most difficult conservation problems. Their values may be long term in nature.

The economic gain in preserving them may not be commensurate to the gain to be derived from destroying them. Thoughtful and debatable questions are raised. Is a family-sized pond rich with many market size species of fish better left uncropped and admired daily while people starve? Or is a magnificent tree of more value growing as a thing of beauty or cut down as timber? One answer is as good as the other but priority should be identified with the more sensitive sphere.

Chapter 3

CAUSE FOR CONCERN

3.1 POLLUTION

Provision of acceptable quality and adequate quantity of water, for fisheries and to satisfy the demand of urban oriented and industrialised societies, is often one of the most critical problems confronting many advanced countries. In many industrialised and even developing countries, the available quantity of water is becoming increasingly degraded as a result of pollution from a variety of sources as shown in Fig. 1.

River pollution occurs when the water is so altered in composition or condition directly or indirectly, as a result of activities of man, that it becomes harmful to life or less suitable for any of the purposes for which it would be suitable in its natural state. Pollution can occur as a result of abstraction of water, which lessens the river volume and its dilution potential, or discharge into the water. The discharged effluents can take the form of poisons, organic and inorganic reducing agents, thermal, oil and inert suspensions.

Before discussing pollution in the United Kingdom, the effects of different forms of pollution are briefly mentioned.

Poisons: From industries and other sources, toxic effluents containing free ammonia, cyanides, sulphides and organic substances are harmful to fish and contribute a substantial biochemical oxygen demand. Basically toxic substances are more lethal to fish in water with low oxygen concentration. Lloyd (1960) found a

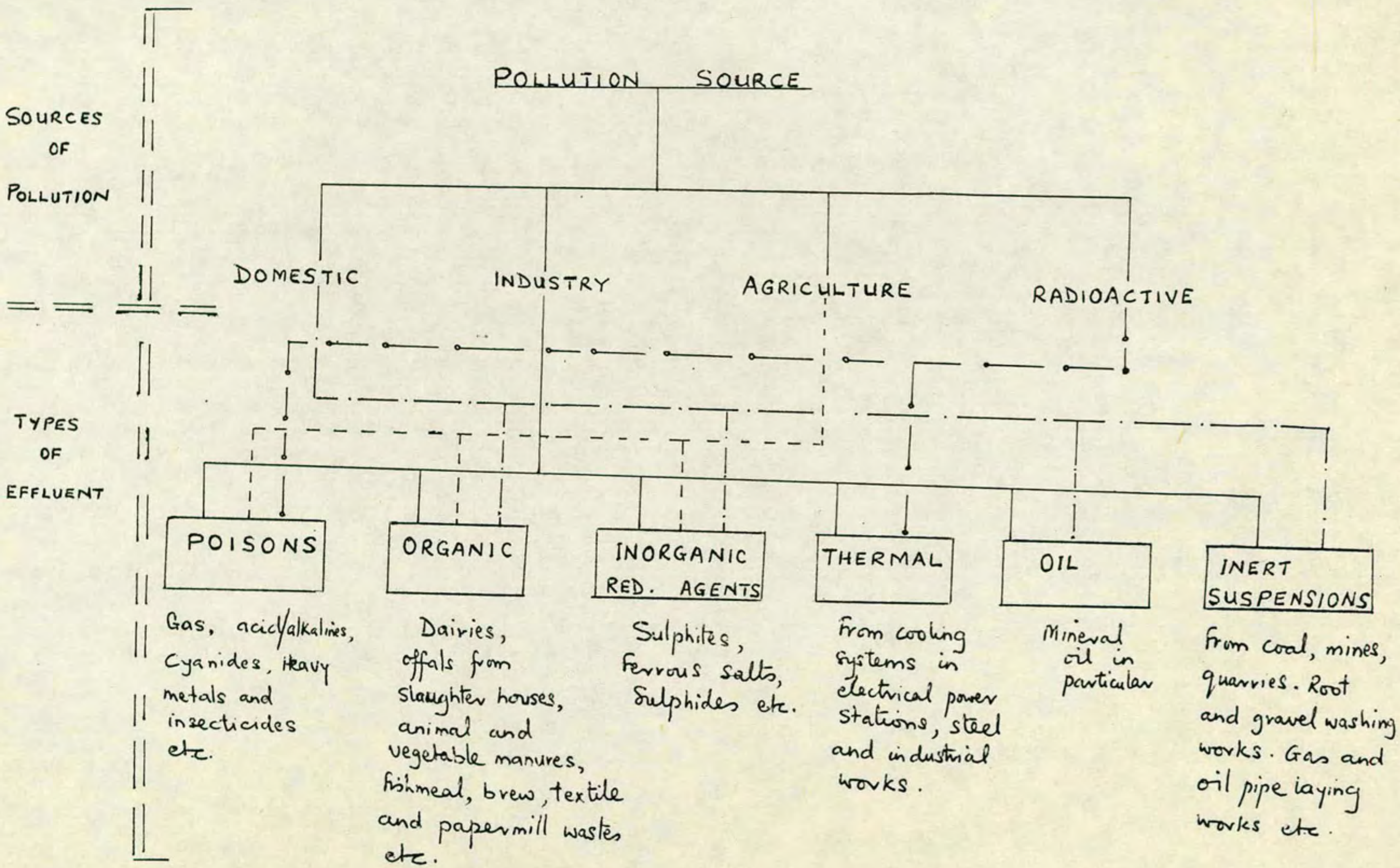


FIG. 1 TYPES OF POLLUTION AND THEIR COMMONLY ASSOCIATED SOURCES OF DISCHARGE

significant decrease in rainbow trout tolerance to zinc ion in waters with low oxygen concentration. He noted that trout survived about 180 minutes in water containing 8 p.p.m. zinc with oxygen content 3.8 p.p.m. while they survived 290 minutes in water with 8.9 p.p.m. oxygen content and the same zinc concentration.

Heavy metals e.g. mercury, cadmium, copper, zinc in industrial wastes not only affect fish adversely, but also other organisms e.g. micro- and macro-fauna on which the fish live. Heavy metals cause acute respiratory stress in fish and a syndrome called co-agulation-film-anoxia which causes their body to be covered with veil-like looking mucus. Zinc compounds also have histopathological effects on the gills, gut and liver of fish, Skidmore (Katz, 1971). Although not much information is available on freshwater fish killed by mercury poisoning, hypertrophy of gill epithelial cells of rainbow trout due to one-hour daily exposure to sublethal dose of ethyl mercury phosphate - E.M.P., has been reported. On exposure the mercury content of the rainbow trout blood reached a level of 16,200 ng/g and with higher increase to 22,000 ng/g in the blood, the hypertrophy became extensive, Rucker & Amend, (Holden, 1972). This level is far above the maximum acceptable limit (1 mg/kg = 1000 ng/g) for human food, LöFroth, (Holden, 1972).

The pH level of water also bears a relationship to the degree of toxicity of many poisons, in water. At pH 7 the toxic effect of ammonium salt is not very expressive even if the ammonium concentration is increased. The unionised form of ammonia is much more poisonous in alkaline water than in acid water while, cyanide is more poisonous in acid water. A concentration of 2 p.p.m. of ammonia in water with pH 8.2 is toxic to fish (Coburn, 1950). Sulphide releases hydrogen sulphide which is deadly to fish in acid water, Wuhrman & Woker (Katz, 1971). Chlorine in the form of hypochlorous acid and chloramines cause fish to lose their equilibrium. They never recover when placed in clean water because the reversible action of the enzyme system is inhibited. About 0.01 mg/l (0.008 mg HOCl/l) of chlorine concentration can be lethal to trout.

Flushings from sheep dips in agricultural and livestock pens generally contain insecticides which can contribute to water pollution. These insecticides are either organo-phosphorus compounds like parathion, malathion and dipterex or chlorinated hydrocarbons - endrin, dieldrin, aldrin and D.D.T. The former compound is less toxic than the chlorinated hydrocarbons. Generally the compounds act by inactivating the enzyme acety-cholinestrase of the nervous system of fish thus inhibiting impulse transmission. This inhibition reduces the ability of the fish to carry on normal life functions - food collection, predator avoidance thus exposing it to death either by starvation or predation. Endrin is the most toxic of all the insecticides examined by Soong and Merican (Hickling, 1971). They found that 0.6 p.p.m. of endrin, dieldrin and aldrin tested separately on fish of the same species and under the same condition killed the fish in $1\frac{1}{4}$ hrs., 5 hrs. and more than 7 hrs. respectively.

<u>Organic</u>: Organic pollution is mostly from domestic, industrial (Food Processing factories) and agricultural wastes. The effluents vary a great deal though they have much in common for they contain complex organic compounds in solution and suspension, often

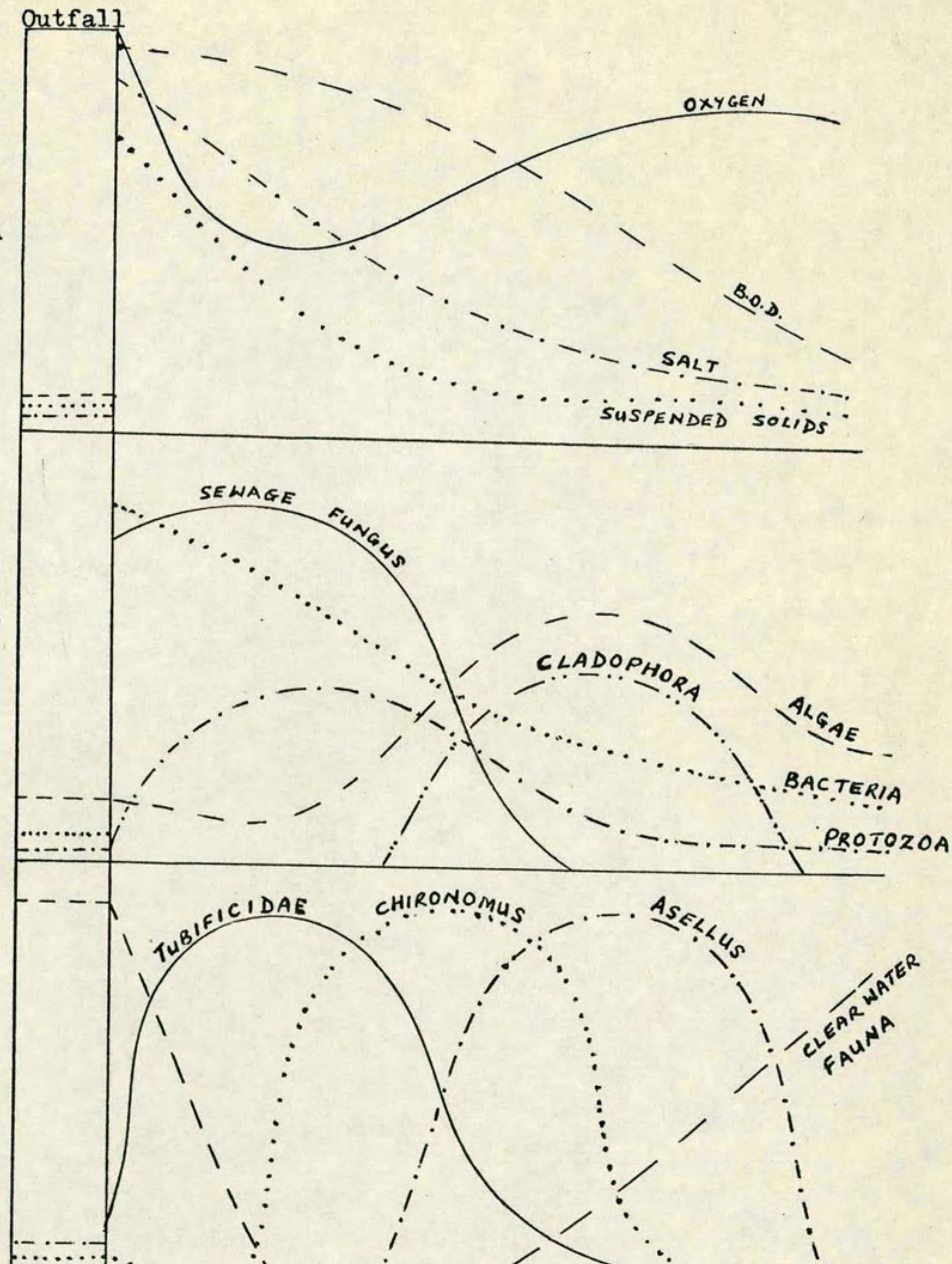
together with toxic substances and various salts. Some of these are more readily decomposed than others. The rate of breakdown depends on bacterial action and the presence of sufficient oxygen for the process. The dissolved oxygen in the river falls sharply if the breakdown is the work of the reducing agents present. But where bacterial action is involved, the dissolved oxygen in the water falls gradually. When the initial oxygen demand is very great the oxygen content of the river may fall to zero for some period. The anaerobic condition which occurs may cause blackening of stream and the development of hydrogen sulphide responsible for a foul odour in some streams. In this situation a mass fish kill may result and only organisms able to tolerate anaerobic conditions can exist.

The general effects of organic pollution and the resulting physical, chemical and biological changes are depicted (Hynes, 1974) in Fig. 2.

<u>Inorganic Reducing Agents</u>: Inorganic reducing agents in effluents also create an oxygen debt in water. These substances like sulphites, sulphides and ferrous salts use up the oxygen in the water to become oxidised. Ferrous waters are usually acid and the ferrous salts which become oxidised often by bacterial action lead to the formation of ferric hydroxide which precipitates on the river bed.

Because of the acid nature of the water and the blanketing effect of ferric hydroxide on the river bed, few organisms occur in the affected area.

Portions of the Rivers North Esk (Midlothian) as shown in Plate I, Almond (West Lothian) and Ore at Laun (Fife) under the



A - Physical Changes

B - Changes in Micro-organisms

C - Changes in Larger Animals

Fig. 2. Diagramatic presentation of the effects of an organic effluent on a river and the changes as one passes downstream from the outfall. (Hynes,1974).

care of the Forth River Purification Board - Scotland are examples of rivers whose beds are rusty red with ferric hydroxide precipitate. These have resulted from the discharge of water from disused and open cast coal mines.

<u>Thermal</u>: Hot water discharges from industrial plants, electric power stations and other heat generating systems that use water for cooling, can cause thermal pollution with effects on fauna and flora.

Higher temperature decreases the tolerance period of organisms, increases reaction time of poisons in effluents and results in low dissolved oxygen concentrations. In order to compensate for the low oxygen, organisms e.g. fish in water tend to increase their respiration rate and with that take in more poisons in the effluent.

Reproduction in fish species is usually temperature dependent. Artificially warmed waters, with other parameters being equal, may induce premature spawning in certain fish species before other conditions suitable for spawning prevail. Fish production triggered off by thermal pollution can be disastrous. The young fish which emerge much earlier than normal may migrate to the usual nursery areas to find that the organisms they normally feed upon are absent. The young will die of starvation and a loss in fish stock will result.

Thermal changes have led to the dominance of diatoms at 20°C, green algae at 30°C and blue-green algae at 35°-40°C in a stream with normal mixed population of algae (Cairns, 1956). Prolonged increases in water temperature helped the spread of aquatic plants like <u>Elodea</u> sp. and <u>Potamogeton</u> sp. (Trembley, 1962).

PLATE 1. Ferruginous discharge at Elginhaugh - North Esk River. The iron precipitate (yellow coloured) effectively cements the stones together thus eliminating the most important habitat for aquatic invertebrates in the river.

(Photo by Forth River Purification Board).

Oil: Oil spills from rigs+, refineries, industries and workshops can be devastating to aquatic life. Phytotoxic oils affect photosynthetic and respiratory metabolism of higher plants and carbon dioxide fixation is inhibited (Dennington et al, 1975).

Inert Suspension: Suspended solid particles can make an aquatic habitat unfavourable to living organisms. They are readily forced out of their habitat as a result of silting up of the stream bed.

These silts generally originate or are pumped out from mine workings, quarrying and tunelling operations. Inert suspensions of soil particles can arise also during gas and oil pipeline operations (Mills, 1976) drainage operations and gravel washings. The inert particles generally disturb spawning sites and grounds, smother fish eggs and fry and invertebrate fauna (Hamilton, 1961).

Inert suspensions also cause water turbidity which prevents light penetration into water. This affects photosynthetic process of plants and the natural food cycle.

+ At the time of writing this thesis there was an oil blow out from a rig, owned by Philip Petroleum Company, in the North Sea. It started on 14th April 1977 and took more than seven days to seal. It was estimated that about 12,000 tons of crude oil was spilled and it covered about 360 sq. miles of the North Sea between Norway, Denmark and East of Scotland, with a threat to their coasts. There was a growing fear that this would be the world's worst oil pollution with disastrous consequences to marine life, (B.B.C. News Report, 20th April 1977). Use of chemical dispersants was refused for fear of adding to the tragic situation. Attempts by Norway to scoop the floating oil with specially designed vessels have not been successful. Incidentally no harm to marine fish has been reported largely because of the quick dispersion of the oil by wave action of the sea (B.B.C. News report, 8th May, 1977).

A lot of chemical and physical factors interact to determine the toxicity of any pollution. The results of pollution on the other hand are largely determined by their effects on organisms whose resistance depends on the species, genetic character, physical state and developmental stage in life.

Scotland, like any industrialised nation, has some low quality waters (rivers, burns and tidal waters) because of pollution. These waters are low in the sense that they are not capable of supporting fish life.

In some areas of the country, little or more than primary treatment of domestic sewage is provided. Where treatment works exist, the plants might often be overloaded and poorly operated and collection systems, at times, might be inadequate. Inland and tidal waters are usually utilised as dumping grounds for the volumes of waste from cities and countrysides. For example, the inshore waters of the Forth are overstuffed with the sewage and trade wastes from Edinburgh area. Accumulation of organic matter in the upper reaches of the Forth estuary in the Forth River Purification Board area, will take years to stabilise. The greater part of the total volume (about 80 million galls. per day) of sewage and trade effluents discharged into the Forth estuary originates from the city of Edinburgh where there are nine outfalls discharging some 60 million gals. of crude/screened sewage and trade effluent. Because of this discharge, the beaches of Leith, Granton and Seafield are grossly polluted and biological surveys of these beaches indicate virtual sterile conditions (Hubbard, 1968). However, Edinburgh Corporation has approved a £16 million scheme designed to provide primary treatment for the principal discharges to meet the conditions laid down by Forth River Purification Board.

Quality survey of inland and tidal waters has revealed that direct discharges of effluents are still made to these waters (Rivers Pollution Survey of Scotland, 1972, H.M.S.O.). These discharges have contributed to the poor quality of some rivers in Scotland. The volume of different effluent discharges made by industries operating in the areas of all the River Purification Boards of Scotland are shown in Tables 1 and 2. Tables 3 and 4 are a breakdown of Tables 1 and 2.

Industrial wastes have made their contribution to some waters e.g. Clyde estuary and Ayrshire coast. In the Clyde, pollution is so grave that a salmon stock is no longer supported. Pollution in this estuary is known to corrode ships and damage cooling systems (Hubbard, 1968). The wastes flowing into Clyde and its tributaries include paper mill pulp waste, iron and steel mill waste waters, concrete products, tannery wastes, bleaching compounds and distillery wastes.

Oil pollution is also a problem, especially at port areas and refineries. Textile wastes from mills have added their contribution as industrial effluents to the streams, although some local authorities such as Galashiels are accepting discharges to their plants (Hubbard, 1968). Papermills have a significant effect on water quality. The Midlothian North Esk has been known to run white with suspended paper fibres as long as a century ago.

The River Don in the North East River Purification Board area contains large masses of sludge as a result of industrial discharges from Mugie Moss (Paper and board maker) and Stoneywood paper mills. About 5 million gals. of effluent with suspended solids are discharged into the River Don by Mugie Moss (Scottish River Purification Adv. Committee Report, 1973). The Ross Poultry

Table 1

Direct Discharges of Trade Effluents to Scottish Surface Water in River Purification Board Areas

figures in thousands of gallons per day (rounded off)

++River Purification Board (RPB) Area	Discharges to Tidal Waters	Discharges to Inland Rivers	Total
Ayrshire	439900	14700	454600
Banff, Moray and Nairn	600	25000	25600
Clyde	240200	403800	644000
Dee and Don	300	15500	15800
Forth	703100	77700	780800
Lothians	910100	15100	925200
Solway	1700	7400	9100
Tay	204200	4800	209000
Tweed	-	900	900
Totals	2500100	564900	3065000
Percentages (%)	82	18	100

(Report of River's Pollution Survey of Scotland, 1972, H.M.S.O.)

++ These are the old River Purification Boards. There are at present eight River Purification Boards which were formed after reorganisation.

Table 2

Direct Discharges of Trade Effluents to Scottish Surface Waters in River Purification Board Areas

Classification by Type of Effluent and Tidal Waters/Inland Rivers

figures in thousands of gallons per day (rounded off)

C L A S S I F I C A T I O N

Direct Discharge to:	Food & Drink Manufacture	Other organic Effluents	Engineering Effluents	Chemical Effluents	Misc.	Totals
Tidal Waters	11600	10400	1300	34000	2442800	2500100
Inland Rivers	48200	46500	42100	5800	422300	564900
Totals	59800	56900	43400	39800	2865100	3065000
Percentages (%)	2.0	1.8	1.4	1.3	93.5	100.0

(Report of River's Pollution Survey of Scotland, 1972, H.M.S.O.)

Table 3

Direct Discharges of Trade Effluents to Tidal Waters
Classification by Type of Effluent

figures in thousands of gallons per day

C L A S S I F I C A T I O N

R.P.B.++ Area	Food & Drink Manufacture	Other Organic Effluents	Engineering Industry	Chemical Effluents	Misc.	Totals
Ayrshire	430	-	-	9464	430000+	439894
Banff, Moray & Nairn	620+	-	-	-	-	620
Clyde	5800	3120	386	-	230879+	240185
Dee and Don	105	105	-	-	100	310
Forth	3228+	3500	900+	19200+	676240+x	703068
Lothians	-	-	-	4550+	905520+x	910070
Solway	1422+	-	-	284	25	1731
Tay	-	3700+	-	480	200000+	204180
Tweed	-	-	-	-	-	-
Totals	11605	10425	1286	33978	2442764	2500058
Percentages(%)	0.5	0.4	-	1.4	97.7	100.0

(Report of River's Pollution Survey of Scotland, 1972, H.M.S.O.)

++ These are the old River Purification Boards. There are at present eight River Purification Boards which were formed after reorganisation.

Table 4

Direct Discharges of Trade Effluents to Inland Rivers
Classification by Type of Effluent

figures in thousands of gallons per day

C L A S S I F I C A T I O N

R.P.B.++ Area	Food & Drink Manufacture	Other Organic Effluents	Engineering Industry	Chemical Effluents	Misc.	Totals
Ayrshire	2002	1	5	5	12657+x	14670
Banff, Moray & Nairn	24997+	-	-	-	-	24997
Clyde	2560	11760	33516	1200	354798+x	403834
Dee and Don	425	15100	-	-	-	15525
Forth	14392+	11209+	8281+	624+	43147+x	77653
Lothians	113	5750	329	-	8950 x	15142
Solway	1560+	70	-	4005	1766 x	7401
Tay	2143	2000	-	-	640	4783
Tweed	-	550	-	-	300	850
Totals	48192	46440	42131	5834	422258	564855
Percentages(%)	9	8	7	1	75	100

(Report of River's Pollution Survey of Scotland, 1972, H.M.S.O.)

++ These are the old River Purification Boards. There are at present eight River Purification Boards which were formed after reorganisation.

Key: (for Tables 3 and 4)

+	Includes cooling water
x	Includes mine or pit water

Classification

Food & Drink Manufacture:	Farming, brewing and distilling, Food processing (milk, vegetables, meat and poultry).
Other Organic Effluents:	Textile, Paper and Board making, Leather tanning and Fell mongering and others.
Engineering Industry:	Iron and Steel, plating and metal finishing and others.
Chemical Effluents:	Chemical and allied industries, Petroleum products, Hospital and Laboratory discharges, Gas and Coke making, others.
Miscellaneous:	Quarrying, coal mining, brick making, Laundry, dry cleaning and electricity generation and others.

Industry used to discharge its washings into the river but with the establishment of Persley Sewage Treatment Works, such a direct discharge has ceased. The load of pollution received by the River Don together with the abstraction made by the industries along the Don,helped to lower the dissolved oxygen concentration of the water thus making it intolerable for salmon and trout. Although no official statistics to confirm the effects of pollution on fisheries, there seems to have been a decline for over ten years. A mass death of smolts in 1972 was reported and this was attributed to pollution (S.R.P.A.C. Report 1973).

Farm wastes from pesticides, silages and piggeries cause severe odours and septic conditions detrimental to fish. Some pollution arising from farm effluents occurred in the Water of Leith but without threat to fish since the discharge was not continuous.

Suspended solids from quarries, mines and coal washings once gravely polluted the River Almond. It turned the water into a brown or black coloured soup, though the effect of this was not sufficient to cause much deterioration of life in the river.

Freshwater and estuary surveys are usually carried out by River Purification Boards. The essence of this is to produce a broad assessment of the condition of the rivers and provide a foundation for future more detailed studies of the state of the rivers. The rivers are divided into four classes of quality on chemical and biological criteria as shown in Table 5. In interpreting and comparing the survey results of the rivers, caution is necessary because of their natural characteristics and the volume of effluent discharge to them. The chemical and biological criteria and technical information involved in quality assessment may vary widely. Also the difference in the distribution of fish within river systems of the

Table 5

<u>Classification of Rivers</u>

(Report of River's Pollution Survey of Scotland, 1972, H.M.S.O.)

Class	Average BOD	Oxygen Saturation	Biological
I	3 mg/l (3-4 mg/l)	$\approx$ 100 per cent	Trout, Salmon, widely diverse invert. fauna, micro organisms sparse.
II	3-8 mg/l	50-100 per cent	Mixed Coarse fisheries, Invert. fauna tending to be restricted, microbes appearing in increasing numbers.
III	8-12 mg/l	$<$ 50 per cent	Moderate to poor fisheries, macroscopic fauna restricted, mostly microscopic organisms present.
IV	12 mg/l	$<$ 50 per cent	No fish, macroscopic invert. fauna absent or severely restricted, microbes abundant.

Remarks: Class I - Rivers unpolluted/and recovered from pollution

II - Fairly good quality

III - Poor quality

IV - Grossly polluted

same chemical quality may be affected by factors e.g. flow, gradient and river bed characteristics other than pollution.

Based on the criteria (chemical and biological) for quality assessment, adopted in the survey of the rivers covered by River Purification Boards, their overall condition has been worked out, Table 6. The total length of the rivers covered by the boards is about 3,200 miles. Of this, 8.3% or 266 miles were in class III and IV categories (poor quality or grossly polluted), and 91.7% or 2,915 miles were in class I and II categories (unpolluted, recovered from pollution or of fairly good quality) (River's Pollution Survey Report, 1972, H.M.S.O.).

Although it is the statutory function of the local purification boards to maintain the cleanliness of inland and estuary waters of Scotland, other bodies e.g. farmers, industrialists, private individuals and associations like the Angler's Cooperative Association assist the boards in solving problems, like pollution, which are of mutual benefits.

The Angler's Cooperative Association's (A.C.A.) (Scottish branch) primary objectives are to fight pollution, protect the interest of angling clubs and others who have fishings and individual anglers and to provide legal and scientific help and when appropriate, to obtain a settlement for pollution damages. If any club or individual member knows of any polluted waters where the Angler's Cooperative Association may be of help, the Secretary of the Association is informed with full details.

In the past the Association has taken a number of actions in principal cases of pollution e.g. gravel and sand workings in Rivers Ugie, Earn and Biel Water (River Almond) where total mortality of fish almost occurred due to an overflow from sandworkings in 1968

Table 6

Total Lengths of Rivers in Various quality Classes in areas of River Purification Boards

River Purification Board (RPB) Area	LENGTH OF RIVER (MILES) Class I	Class II	Class III	Class IV	Totals
Ayrshire	172	82	29	4	287
Banff, Moray & Nairn	400	39	2	1	442
Clyde	147	138	56	67	408
Dee & Don	277	5	1	3	286
Forth	224	65	24	7	320
Lothians	55	51	45	12	163
Solway	474	24	2	4	504
Tay	392	27	5	0	424
Tweed	332	11	3	1	347
Totals	2473	442	167	99	3181
Percentages	77.8	13.9	5.2	3.1	100

Source: Report of River's Pollution Survey of Scotland, 1972, H.M.S.O.

(A.C.A. Ann. Report 1969). Actions have also been taken for pollution due to oil spillage on Rivers Ruel, Dee and Pomfeigh Burn (Lanarkshire) where a claim by a club that discharge of oil had affected their hatcheries. Many cases of industrial and sewage effluent discharges have been looked into e.g. in the River Eden, where salmon, sea and brown trout were killed by industrial effluent from a mushroom factory; in the River Don where two paper mills and a food processing factory were discharging their effluents and in the River Leven where cyanide discharge was being investigated and where a loss of hundreds of brown and sea trout had already been sustained due to this cyanide discharge.

From the survey and available data there is every indication that Scotland is fighting relentlessly to keep pollution from her waters despite her industrial and population growth. The credit is not only that of the local purification boards and authorities but that of the willing industrialists, watchful Associations, clubs and individuals who know the consequences of pollution.

England: Some rivers in England particularly in the industrial areas of Midlands and Yorkshire are badly polluted due to trade effluent discharge. The most seriously polluted rivers are consistently of poor quality and incapable of supporting fish life. Some of these rivers lie in the west of Yorkshire and are under the care of Yorkshire Water Authority. The rivers further north of Yorkshire are of much higher quality but their use for water supply, game fisheries and recreation results in pollution being more noticeable and having more obvious consequences.

The Rivers Tyne and Don (Yorkshire) among others in England are affected by pollution mostly from industries. These rivers used to support salmon but today the situation is greatly changed as in River Tees. Between 1905 and 1925 the River Tees supported an average catch of 6,500 salmon. Since then the number has declined, Fig.3, due to pollution. The river no longer supports salmon on any significant scale either for anglers or commercial nets. The estimated loss is about 32 tons or £30,000 yearly.

Most of the reaches of the Don and tributaries are situated in some of the most densely polluted and highly industrialised zones of Yorkshire. The River Don is degraded to class IV category and worsened more by the acidic and ochreous drainage from Bullhouse colliery. Also serious incidents of oil spills on the Don have been reported.

River Aire another grossly polluted river in Yorkshire is degraded to class IV category due to the effluent from sewage works of Esholt (Bradford Corporation) and Leeds Corporation.

The River Wharfe is polluted by brewery and papermill discharges as well as domestic sewage discharge which has caused the growth of sewage fungus and algae that have led to the fouling of anglers' lines and keep nets at Tadcaster (Yorkshire Water Authority Ann. Report 1973).

Cases of pollution due to coal mine discharges are not uncommon in Yorkshire. The mine water pumped out may be acid and contain salts of reduced iron which precipitate out when it oxidises on entry into a watercourse. The Yorkshire Water Authority, unfortunately cannot deal with such discharges because they are exempt under the Rivers (Prevention of Pollution) Acts. This leads to considerable concern by the Yorkshire Water Authority as

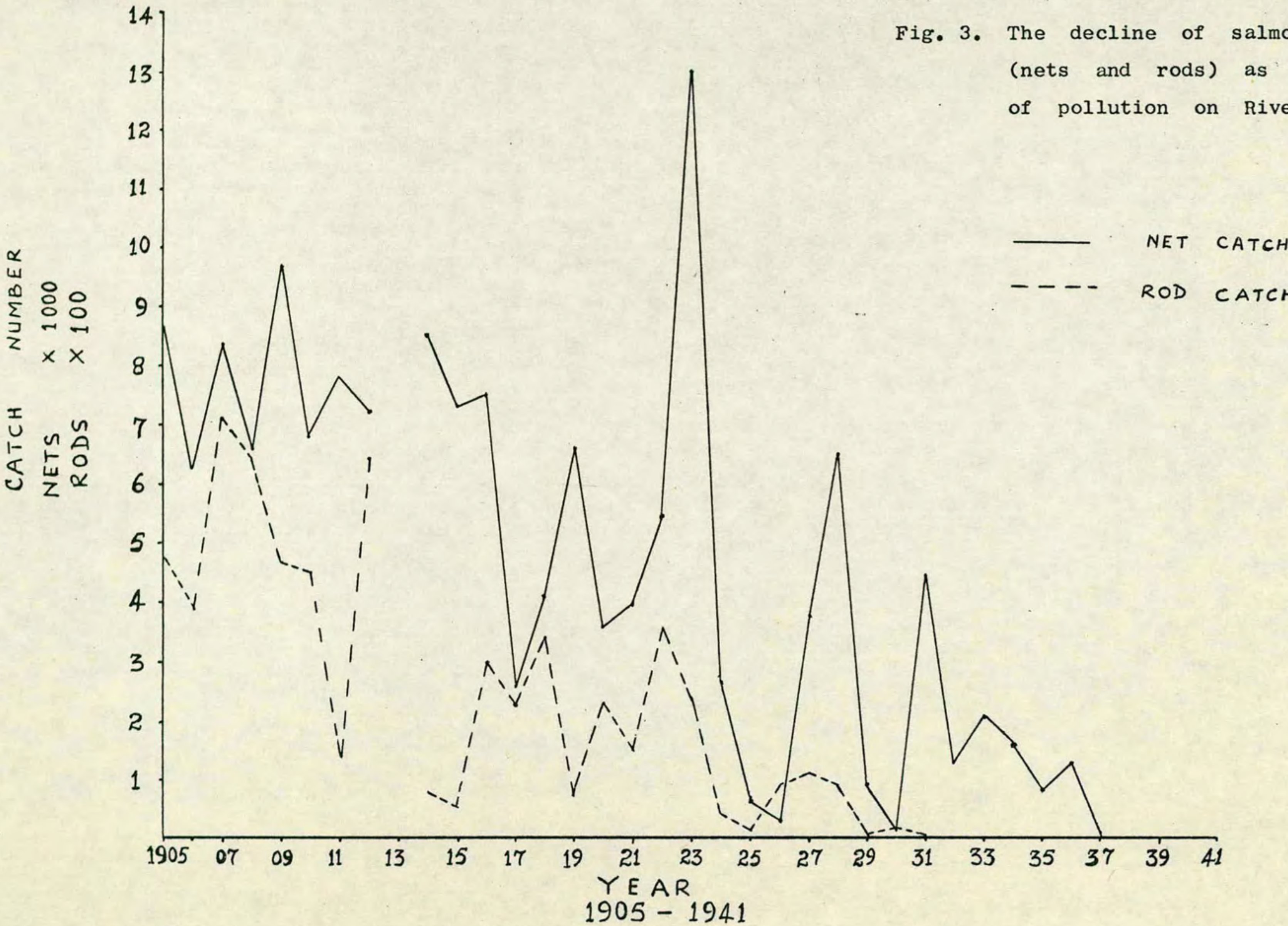


Fig. 3. The decline of salmon catches (nets and rods) as a result of pollution on River Tee.

it means that more rivers can deteriorate in classification with the spread of such a discharge.

About seventy-four reports of fish kill due to pollution in the Yorkshire Water Authority area were investigated between 1972-73. For example an undetermined number of coarse fish were killed in the River Dearne as a result of leakage of tip drainage of a local authority sewage works into a feeder stream. Furthermore, farm effluents caused a substantial kill of coarse fish in a pond in 1962. Silage killed about 750 trout and 400 roach and perch in Coxley Dam near Wakefield and about 1500 fish were killed in the Cod Beck due to drainage from silage manufacture in a nearby farm (Yorkshire Water Authority Ann. Report 1973).

Industrial effluent containing cyanide from a plating plant entered Leeds and Liverpool canal at Rodley and caused the death of several hundred coarse fish. Effluent from cement plant is known to have caused the death of 300 trout at Cowhouse Beck (Y.W.A. Ann. Report 1973).

The system of river classification based on chemical and biological criteria is basically the same as in Scotland. River pollution survey has shown the following rivers, Table 7, in Yorkshire to belong to different class categories at some portions because of intermittent occurrence of pollution from industries.

Pollution of inland waters in Nigeria is not on any significant scale. Industrial growth is not such as to cause heavy trade effluent discharge into the inland waters.

Domestic sewage is the main pollution threat to inland waters. The tipping of domestic sewages into inland and tidal waters is usually a common practice in developing countries. Although no account of the effect on aquatic life such a system of sewage

Table 7

River Pollution Survey Result in Yorkshire Water Authority areas

		LENGTH	CLASSIFICATION		
Rivers	Catchment Area Sq. miles	Class I	Class II	Class III	Class IV
Don and Tributaries	669.4	187.1	92.2	52.1	160.3
Aire " "	794.8	348.1	104.2	44.4	165.7
Wharf" "	389.6	276.1	4.1	-	-
Nidd " "	210.7	193.1	-	-	-
Ure " "	955.9	816.4	3.3	-	-
Derwent " "	784.6	569.7	2.0	-	-
Ouse " "	369.8	232.0	22.6	0.8	27.2
Esk " "	139.9	109.4	-	-	-

Source: Yorkshire Water Authority, Annual Report 1973 disposal in Nigeria has been documented, there is no doubt that the practice will facilitate the spread of disease and parasites by fish, crustaceans and other animals either as intermediate or final hosts.

Where human wastes and sewage are dumped into inland waters, there are possibilities of transmission of disease parasites e.g. typhoid and cholera bacteria to human beings. Munn (1976) indicated the dangers in the use of human sewage effluent in inland waters (Chapter 3.5). In China high death rates estimated at 28-30 per thousand annually are caused by diseases transmitted by night soil in inland waters (Schuster et al, 1954).

Dasmann et al (1973) noted that the disposal of domestic sewage into inland waters in the Far East has some disastrous consequences. For example parasitic worms (tapeworms and some nematodes) and flukes like Schistosoma sp. have found their way through fish, crustaceans and snails as intermediate hosts to man.

Disease and parasites not-withstanding, other side effects of pollution e.g. oxygen shortage due to high biochemical oxygen demand as mentioned earlier must have contributed to losses in fish stock in developing countries.

3.2 WATER ABSTRACTION

Water schemes are established to satisfy domestic and industrial water demand. Sources of water supply can be (i) underground (ii) surface waters (rivers, streams and natural bodies of water) (iii) reservoirs - man-made lakes.

In the underground source, the water is stored in the fissures and pores of the rock or in the pores of gravel deposits within the water table. The method of tapping such water is usually by bore-holes and well construction.

Surface flowing waters (streams and rivers) also serve for water supply. The supply may be by direct drawing from the stream or indirect from reservoirs fed by the surface waters.

Man-made reservoirs which serve for water impoundment can be of three categories:

(a) Direct-supply impounding reservoir: This is established in the higher valleys from which the water is piped (usually by gravity) to points of use.

(b) Intake or pumped storage reservoir: This is usually built on a site which has no adequate catchment because of the geographical feature of the area.

(c) Regulatory reservoir: This is used to maintain the flow (by release of compensation water) in the river below the reservoir and to supplement the flow during low flow periods so that water can be abstracted some distance downstream.

For a specified yield, the amount of storage required is dependent upon the characteristics of the river from which the reservoir is fed or which it regulates.

Water abstractions fall into two broad categories, direct and indirect. Direct abstraction is the removal of water straight from the rivers and streams while the indirect is by taking water from storage reservoirs which are fed by rivers and streams.

A reservoir cannot be created in the United Kingdom without the authority of Parliament. This authority given has the same legal effect as an Act and it will not permit the complete stopping up of flow of a river. The riperian owners have Common Law rights to the use of the river water and these rights must be protected. Thus, a farmer's sheep or cattle may drink from or be watered from a clean river and this farmer's living would be damaged if the establishment of a reservoir stopped the stream or river flow.

During dry weather river flow is generally small and this may be quite insufficient for farmers and other riperian owners. Further more the river may be used as dilutant for sewage effluents, for factory processing, and for cooling purposes thus making it more insufficient. Added to this, are the interests of fishermen who naturally will like to see the river full and flowing. All these interests will join together to protest at the diminution of the flow of the river even during the wet weather.

It is therefore the duty of the government to adjudicate between the disputing parties and fix, as a result, the compensation flow which must be given out from the reservoir. The compensation flow is the minimum quantity of water which must be maintained in the river immediately downstream of the dam. Such a flow is usually stipulated as being required to be discharged in a uniform manner, though sometimes a greater discharge is made in summer than in winter; or there may be provision for special discharges at certain times of the year to aid fish life.

The abstraction of surface water tends to conflict with the well being of fisheries which require water in situ. It is one of the many tasks of Water Boards, River Purification Boards, Fishery Boards and Water Authorities to resolve this conflict. This is not easy since the prerequisite for an equitable solution depends on accurate assessment of fishery requirements which are based on scientific data. However, the authorities, Fishery Boards and Water Authorities concerned with fisheries have often gone into agreements with Water Boards and other statutory water undertakings on the quantity of water to be released for an optimal upkeep of fisheries.

During very difficult weather conditions e.g. dry and long sunny periods, water levels usually drop because of drought and increased demand by consumers. In the circumstance Water Boards and water undertakings tend to reduce the release i.e. compensation water, downstream to keep up public water supply, as the case with Loch Lee in the area of North Esk District Fishery Board in Scotland. The Water Board (East of Scotland)+ in this area sought authority to reduce the average flow in the river to save Loch Lee that was beginning to run short of water. This reduction would have a resultant effect on fisheries, the North Esk Fishery Board claimed. The Fishery Board raised objections, called for Public Enquiry (which was not heard) and later gave way to the pressure of the Water Board because of the critical situation of the water supply which could run out within 23 days.

+ Now Water Division of Tayside Regional Council. Other Water Boards in Scotland referred to in this Chapter are now Water Divisions of Regional Councils.

In protest against the Tayside Regional Council (Loch Lee) Emergency Water Order 1976, to reduce the average flow by 10%, the North Esk Fishery Board declared:

> "The Tayside Regional Council (Loch Lee) Emergency Water Order 1976 threatens the foundation of the work of the N. Esk District Fishery Board and the industry which depends on that work .... The purport of these objections was that the order would result in at least 10% decrease in the flow of the river as a whole and apart from immediate harm, this would entail a fall of at least 10% in fish population and subsequent equivalent decline in catches and of the dependent industry ...."

In apprehension of a repeated occurrence of drought condition and with implementation of the Water Board proposals to take water from Loch Lee because it is slightly cheaper and possibly increase abstraction from Lee area by a further 60% in the North Angus, the North Esk Fishery Board declared:

> "If the present drought circumstances are repeated and if these plans are put into effect, the North Esk Fishery Board believe there is a risk that parts of the river will be run completely dry in future years. The rivers of Scotland are a priceless heritage and their destruction would be a terrible

thing. The North Esk can never be replaced; it is a miracle of nature and is a source of endless pleasure to the public............"

Although the North Esk Fishery Board eventually gave in to the Water Board to avoid the occurrence of a wider damage by failure of Loch Lee supply to consumers, their protest indicates the viciousness with which they and other Fishery Boards fight against water abstractions in their areas. Similarly the River Purification Boards of Scotland in co-operation with Fishery Boards help to conserve water for fisheries just as the Tay River Purification Board was requested by North Esk Fishery Board to apply the Spray Irrigation Control Order to conserve water in the area.

Within the 77,000 sq. kilometers of Scotland (68,000 being on the mainland and 9,000 sq. kilometers in the islands off the Western and Northern shores) rainfall varies widely. In the mainland it ranges from a maximum of 3800 mm per annum in the Highlands of Wester Ross to a minimum of 600 mm in the coastal areas of Moray Firth and in East Lothian. On the average it is about 1400 mm per annum throughout Scotland. The total runoff to the burns, rivers and to the sea after the losses (evaporation and transpiration) can be estimated to be 73,000,000 megalitres yearly (i.e. average of 200,000 ml/day), (Water Resources in Scotland, 1973 H.M.S.O.). Working with a population of 5.1 million^{+}, it would seem there is a lavish supply of water per head in the mainland. But with developments and industries, this quantity is greatly reduced and there is a request for economy on use of water.

Water supply in Scotland by the Water Boards as shown in Table 8 is mostly from surface sources e.g. natural lochs, reservoirs, burns and rivers. Little is drawn from underground

TABLE 8 ***Public Supplies: Population and Domestic, Trade and Unit Consumptions for each Water Board in Spring 1971***

(Water Resources in Scotland, 1973, Scottish Devpt. Dept.)

*Water Board***	*Census population (1,000)*	*Consumption (Megalitres per day—Ml/d)*			*Unit consumption (litres/head day)*			*% Consumption*		*Estimated population not receiving public supply*	
		Total	*Domestic*	*Trade*	*Total*	*Domestic*	*Trade*	*Domestic*	*Trade*	*Number (1,000)*	*%*
Boards in Central Area											
Ayrshire and Bute	375	185·7	126·3	59·4	495	336	159	68	32	1–3	0·3–0·8
East of Scotland	429	138·0	100·2	37·8	322	233	89	72	28	12·5	2·9
Fife and Kinross	328	108·0	75·0	33·0	329	229	100	69	31	1·2	0·4
Lanarkshire	562	204·3	140·0	64·3	364	249	115	68	32	1–2	0·2–0·4
Lower Clyde	1,501	722·9	479·3	243·6	482	319	163	66	34	2	0·1
Mid-Scotland (3)	319	203	87·6	41·7 (73·7)	636	275	130 (231)	43	21 (36)	0·7	0·2
South-East of Scotland	854	273·9	181·4	92·5	321	213	108	66	34	2–4	0·2–0·5
Totals (and averages) for Central Area	4,368	1,835·8	1,189·8	646·0	(420)	(272)	(148)	65	35	20·4–25·4	0·5–0·6
Boards in Country Area											
Argyll	59	22·0	21·6	0·4	373	366	7	98	2	5	8
Inverness-shire	89	28·6	21·3	7·3	321	239	82	74	26	9	10
North of Scotland	76	28·5	23·3	5·2	375	307	68	82	18	3	4
North East of Scotland	434	127·5	80·2	47·3	294 (335)	185 (211)	109 (124)	63	37	39	9
Ross and Cromarty	59	26·3	19·0	7·3	446	322	124	72	28	5	8
South West of Scotland	143	61·8	36·4	25·4	432	255	177	59	41	9·6	7
Totals (and averages) for Country Area	860	294·7	201·8	92·9	(343)	(235)	(108)	68	32	70·5	8
Totals (and averages) for all areas	5,228	2,130·5	1,391·6	738·9	(407)	(266)	(141)	65	35	90·9–95·9	1·7–1·8

Notes

1 'Trade' consumption is the consumption which is metered by boards to larger consumers and charged accordingly. It includes also a few bulk supplies to industries of non-potable water which may not be metered.

2 'Domestic' consumption is the remainder which is unmetered and is composed mainly of consumption by households, smaller (unmetered) trade supplies, temporary supplies such as to building sites and for fire-fighting, and includes mains washwater and leakage and sometimes treatment washwater.

3 For Mid-Scotland Board the special industrial supplies at Grangemouth have been shown separately in brackets.

4 The unit consumptions have been calculated throughout the report from the census population neglecting the effect of the estimated population not receiving a supply.

5 The figures of population not receiving a public supply are a very approximate estimate and are intended to be indicative only.

6 The bracketed unit consumption figures for the North-East Board are those adjusted to eliminate restraints in force at the time of the survey.

** Water Boards are now called Water Divisions of Regional Councils of which there are as follows:- Borders, Dunfries & Galloway, Fife, Grampian, Highland, Lothian, Orkney & Shetland, Stratheclyde, Tayside and Western Isles.

waters (springs, wells and boreholes). The domestic unit consumption throughout Scotland is about 266 litres per head daily (57 gals. per head per day). This is well above the figure for England and Wales which is about 185 litres per head per day (40 gals. p.h.p.d.), (Water Resources in Scotland, 1973 H.M.S.O.). Table 8 is a breakdown of public supplies for 1971.

Private abstractions for domestic and farm supplies are generally piped from springs, lochs and burns. These abstractors which are about 1.8% of the population form a relatively insignificant group. The total net abstraction for private purposes is about 132 Ml/day as shown in Table 9. It is most likely that this quantity is not returned to the water. Although the quantity appears insignificant, it is substantial. The net abstraction i.e. water abstracted and not returned locally to the source has not yet manifested any adverse effects. This could be due to the substantial amount of rainfall which replenishes the surface waters. However, with the population growth, industries and occasional periods of drought, a loss of 132.5 megalitre per day plus the normal domestic consumption (under the public supplies) of 266 megalitres/day which are usually lost, the effect of water consumption could be detrimental on fisheries and other water uses.

England and Wales: Direct abstraction takes about 80% of the total licensed abstraction which is in the region of some 44 million m^3/daily in the Midlands of England and in Wales (Water Res. Board Ann. Report, 1971). Although such a large percentage of abstraction is made, some industries have been known to use and

TABLE 9. Private Abstractions: Types of Sources

(Water Resources in Scotland, 1973, Scottsh Devpt. Dept.)

Megalitres per day (Ml/d) = 1,000 m^3/d

Water Board Region*	General Abstractions								Electricity Boards				Canals			
					Underground Sources											
	Reservoirs		River Intakes		Boreholes and wells		Springs		Hydro-electric reservoirs and river intakes		Thermal cooling water—river intakes		User abstractions		Total abstractions	
	Gross	Nett	Gross	Nett	Gross	Nett	Gross	Nett	Gross	Nett	Gross	Nett	Gross	Nett	Gross	Nett
Ayrshire and Bute	—	—	5·0	5·0	—	—	—	—	400	—	5	—	—	—	410	5·0
East of Scotland	—	—	2·5	2·5	—	—	—	—	6,700	—	—	—	—	—	6,702·5	2·5
Fife and Kinross	—	—	19·5	10·1	15·9	15·9	—	—	—	—	—	—	—	—	35·4	26·0
Lanarkshire	—	—	—	—	—	—	—	—	540	—	—	—	11·4	2·9	551·4	2·9
Lower Clyde	—	—	148·3	40·6	—	—	—	—	540	—	910	—	145	4·1	1,743·3	44·7
Mid-Scotland	6·4	6·4	4·7	4·7	3·3	3·3	—	—	—	—	—	—	66·9	0·2	81·3	14·6
South-East of Scotland	—	—	900·2	22·9	1·0	1·0	—	—	—	—	—	—	16·7	12·9	917·9	36·8
Totals for Central Area	6·4	6·4	1,080·2	85·8	20·2	20·2	—	—	8,180	—	915	—	240·0	20·1	10,441·8	132·5

Notes

1 The figures are approximate, not all inclusive and indicative only of the general scale of usage.

2 'Nett' usage is the amount of water which is abstracted and not returned locally to the source. 'Gross' usage is the total abstraction including water returned locally such as water circulated for cooling purposes. Hydro-electric abstractions are tabulated in this category.

* Water Boards are now called Water Divisions of Regional Councils and are as shown in Table 8.

reuse effluents many times along the course of some rivers e.g. River Trent. Direct abstraction for agriculture in comparison with other industrial abstractions is relatively small.

In the Midlands of England and in Wales, the total abstracted quantity of water in 1969 by industries (including the Central Electricity Generating Board) and agriculture was about 36,395,000 m^3/daily. Of this quantity 29,370,000 m^3/daily was used by the Central Electricity Generating Board (C.E.G.B.) for hydroelectric power generation and cooling the nuclear power station in Trawsfynydd Lake, Table 10. Agricultural-licensed abstraction was 170,000 m^3/daily by December 1969 and two thirds of this was for spray irrigation particularly in the areas of the then Severn-Trent and Lincolnshire River Authorities as shown in Table 11. The summary in Tables 10 and 11 shows the extent of water abstractions from rivers and streams.

The Midlands of England and Wales include some of the wettest and driest zones. The mean annual rainfall ranges from 4500 mm in Wales to 600 mm in Lincolnshire. With sufficient rainfall on the upland areas in winter as against the lowland area where demand is more, it is proposed to establish a storage capacity so that the water thus stored could be distributed to the lowland areas. The stored water would best be used for river regulation i.e. to increase river flow when it would otherwise be low. This would give a much greater yield than when used for a direct supply because it would reduce the delivery cost by conveying water to the river itself than to an aqueduct. It also gives other benefits to the river. It can also be managed to give a measure of flood control.

Table 10

Central Electricity Generating Board (C.E.G.B.)

Licensed Direct Abstractions (1969)

+River Authority	(expressed in 1000 m^3/d) Quantity (approx. 5000 m^3/d)
Dee & Clwyd	15
Trent	9730
Lincolnshire	180
Severn	4085
Bristol Avon	-
Wye	-
Usk	2130
Glamorgan	260
South West Wales	5760
Gwynedd	7210
TOTAL	29370

The quantities shown above include water abstracted by CEGB from both non-tidal and tidal sources for thermal power generation and hydro-power.

(By the courtesy of Water Res. Board)
H.M.S.O. London, 1971.

+ River Authority now Water Authority with reorganised catchment areas.

Table 11

Industry (Excluding C.E.G.B.) & Agriculture

Licensed Direct Abstraction (1969)

(expressed in 1000 m^3/d)

+ River Authority	Industry No. of Licences	Quantity	Agriculture (Including Spray Irrigation) No. of Licences	Quantity
Dee & Clwyd	92	475	400	5
Trent	994	3590	2150	38
Lincolnshire	166	275	1202	40
Severn	446	250	3397	59
Bristol Avon	121	335	294	3
Wye	75	55	1788	16
Usk	71	180	150	1
Glamorgan	152	1370	52	1
South West Wales	123	130	620	5
Gwynedd	67	195	55	0.5
TOTAL				
Wales & Midland	2307	6855	10108	170
The North x	2857	10250	4883	170
The South East x	2480	3835	11007	485

(By the courtesy of Water Resources Board 1971)

\+ River Authority now Water Authority with reorganised catchment areas.

x For comparison with Wales and Midlands of England.

The Rivers Wye, Severn and Trent are the main rivers that supply water to the Midlands and Wales. The River Wye is the cleanest of the three with only small portions of effluent in its lower reaches. There are direct supply reservoirs on its tributary - the Elan. These reservoirs - Birmingham Corporation direct supply reservoirs - divert some 350,000 m^3/day of water by aqueduct to the area of the former Trent River Authority.

The River Severn receives effluents along most of its course. It has the Liverpool Corporation direct supply reservoir in its tributary - the Vyrnwy. This diverts some 200,000 m^3/day of water by aqueduct to Liverpool. There is also another regulating reservoir on the Severn's tributary - the Clywedog. This enables abstractions to be made along the Severn.

The River Trent receives a large volume of sewage effluent from the West Midlands in its upper reaches. The quality of the River Trent depends upon the quality of the effluent it receives. These effluents amount to more than half the dry weather flow of the river. It has a direct supply reservoir on its tributary - the Derwent. This diverts some 225,000 m^3/d to Sheffield, Derby, Nottingham and Leicester.

Though the average daily flows of these rivers are not shown, it places one in a position to reflect on the possible effect of water abstractions on aquatic life, particularly in areas of little rainfall.

Water abstraction can affect inland fisheries directly and indirectly. Accordingly, migratory fish e.g. salmon and sea trout are more vulnerable to variation in water discharges than the non-migratory trout and coarse fish. A discharge sufficient to maintain bare survival may discourage migration, prevent spawning and hinder their capture by rod and line. Although many factors including light changes and fairly strong onshore winds (Hayes, 1953), rise in temperature (Menzies 1931), physiological variations in the thyroid activity as the salmon becomes sexually mature, Fontaine (Mills, 1971) are said to influence fish migration, a rise in water level, release of artificial spates and discharges seem to influence fish migration more. Baxter (Brayshaw, 1967) described discharges as proportions of average daily flow (a.d.f.) and noted that salmon will ascend most rivers in flows varying 30-50% of the average daily flow in the lower and middle reaches to 70% in the upper reaches and streams of the headwaters.

Abstraction for reservoir development can contribute negatively to fisheries by causing flooding of spawning, nursery and feeding grounds and also obstruction and delay to migration. Spawning activity is impaired due to spawning migration inhibition and natural recruitment of juvenile fish is reduced. Gudjonsson (Mills 1971) commenting on the effects of water abstraction on salmon in River Ulfarsa, Iceland, noted that about 281 salmon (about 61.5% of the predicted average yearly catch) between 1954 and 1963 was lost due to abstraction of one fourth of the volume of water to a fertilizer factory. He attributed these losses to damage to stock by a drainage pipe to the factory, impaired living conditions and drying of the river bed during the winter period.

Millichamp (1976) noted that the effects of water abstraction on migratory fish depend not very much on the volume of water removed within a short interval, but more on prolonged duration of abstraction. For example if the flow of a river is 200 cusecs and this is slightly above the minimum fish attraction flow, then in a ten-day period one abstraction of 150 cusecs in 24 hrs. will have less effect upon the migration than an abstraction of 15 cusecs daily during the whole of the ten-day period. In the first instance migration would stop for 24 hrs. and in the second instance it would stop for 10 days when, all other parameters being equal, the fish could have moved at will but the abstraction in both cases would be the same.

Better angling prospects exist for coarse fish and non-migratory trout than salmon. The reason for this being that both coarse fish and trout can be caught under low flow conditions. However, with salmon many factors e.g. time of season and discharge, water temperature and obstacles (e.g. weeds) combine to make angling less predictable. Success of salmon angling, apart from other factors greatly depends on water discharge and with a discharge range of over 0.7 to 1.5 x the average daily flow, successful angling can reach a peak (Brayshaw, 1967).

In general water abstraction can lead to changes in water velocity, turbidity, suspended solids, temperature, low dissolved oxygen, fluctuations in pH, conductivity and water hardness. All these features affect the distribution of fish, fish food and other organisms in the environment. Some invertebrate fauna not very capable of a firm attachment to the river-bed substrates can easily be dislodged by changes in water velocity.

Although changes in the river flow (velocity) may govern the willingness of salmon to occupy certain stations, it is difficult to envisage how this alone brings it about. It seems to integrate with other factors already mentioned. It is known that fish are capable, physiologically, of responding to changes in velocity which in turn is much governed by the gradient of the river bed.

It is not often easy to determine the optimal level of water required for successful spawning and migration upstream. In an attempt to protect fisheries, a minimum acceptable flow (MAF) has been laid down by the Water Resources Act 1963. By this Act and on the basis of the scientific knowledge of the river flow, water authorities are to fix minimum acceptable flows for rivers in their areas, having regard to the need for safeguarding fisheries, amongst other things. A suggestion that the M.A.F. should be proportions (about $\frac{1}{4}$ or 1/8) of the average daily flow (adf) depending on the time of the year has been made by Baxter (Law 1966). Various suggestions put forward on the amount of water (i.e. percentage of adf) required to safeguard the interest of fisheries may be satisfactory for rivers containing non-migratory species, but in salmon and sea trout rivers the position is more complicated. Migratory fish can enter a river from the sea and move upstream at far lower flows than those at which they are caught (Millichamp and Lambert, 1967). It follows that sufficient flows to allow migration do not necessarily provide suitable condition for catching these fish. The aim of the Water Resources Act 1963 is not just to allow enough flow for fish migration but also to give optimum condition for their catchability by anglers. The determination of this minimum acceptable flow for fisheries, is therefore a task for Water Authorities and fisheries administrators. It is a task demanding a long term study involving knowledge of yearly inflow, frequency and length of drought periods and average daily flow, pollution influence, silt load in flood periods and general water quality.

In practice a fixed value of M.A.F. should not be rigid. Rather, common sense instead of rigid law enforcement should prevail in determining what the M.A.F. should be,considering the time of the season and other uses of the water e.g. navigation, agriculture, amenity and recreation. Where the point of abstraction is above tidal influence and no significant fisheries downstream, water abstraction at low flows should not be unduly restricted.

3.3 HYDROELECTRIC DEVELOPMENT

Energy demand of the United Kingdom has so far been met by exploiting readily available sources and many of these have been developed as far as possible. In the U.K. much of the period since the industrial revolution has been founded on coal and from its enormous reserve, there is still sufficient coal to meet the demand for long time supply of energy.

The use of petroleum products e.g. oil and gas for energy supply, was for some time popularly resorted to. Their probable decline as sources of hydrocarbons for combustion in power stations must have been because of their uncertainty in long term use. Nuclear power is also being harnessed for energy supply.

Although coal, oil and gas qualify as sources of power supply since many are in commercial operation, hydro power supply seems to have an unqualified advantage over these.

(i) Fossil fuel are impossible to guarantee absolutely and their prices are not readily controlled.

(ii) High interest rates render capital-intensive power stations unattractive unless they have very low fuel costs. Continuing fuel escalation has in recent years made fossil fuel plants a less attractive economic proposition.

(iii) Because of the overall simplicity of operation, power stations e.g. hydroelectricity drawing upon the renewable sources are inherently less susceptible to disruption for political reasons.

(iv) Hydroelectricity reduces the environmental costs by preventing the build up of air and water pollution problems connected with fossil fuels and radioactive waste disposal.

Hydroelectric schemes generally follow a conventional pattern which may be any of these four main types of installations:

(a) A simple dam or barrage to divert water for use in another catchment area.

(b) A larger but simple dam with generating station some distance downstream. The water from the dam simply passes through the generating station to produce power and the water released downstream of the power house.

(c) May be a combination of (a) and (b).

(d) Pumped-storage reservoir which is at a higher level than and some distance from the power station. This provides a greater head of water so that less water is required to produce the same amount of, or more electricity than in the type (b).

Where the natural catchment area is not enough, the water available to the scheme is increased by diverting to it streams by means of aqueducts, which normally flow in other directions. Despite the existence of many good reservoir basins, few, if any provide a really easy site for the dam. The rock, in the river bed, is of widely differing character and therefore each site produces its own problems resulting in a wide variety of design of dam e.g. buttress dams of various designs, plain gravity type and the Arch type usually common in the continent because of the narrow steep sided rock gorges present.

By 1943-64, there were about fifty-five hydro electric power stations in operation in Scotland. In reaching this level of development, some fifty percent of the potential water power in Scotland has been harnessed. In addition to these conventional hydroelectric developments, the developments of large pumped storage schemes have not been neglected. A typical example of this, is the Awe scheme.

The Awe scheme has three separate sections - Cruachan, Inverawe and Nant. The Inverawe and Nant sections are conventional hydroelectric projects.

The Cruachan section is the first large-scale pumped-storage hydroelectric development in Scotland. Energy from the South of Scotland Electric Board's (SSEB) system is used to pump water from Loch Awe to a high level reservoir on Ben Cruachan. The pumping is done at night and at weekends when the demand for electricity is light. The Cruachan storage which is also supplemented by water diverted from about $6\frac{1}{2}$ sq. miles by tunnels and piped aqueducts, is used to generate electricity at times of peak demand. The Cruachan reservoir has a dam of 1,315 ft. above sea level, two inclined shafts leading to an underground power station containing generators driven by reversible pump/turbines and a tunnel between the upper station and a screen bay at the side of Loch Awe. The Cruachan reservoir has a storage capacity of 350 million cubic feet. The water is impounded by the 153 ft. high dam built across the Allt Cruachan stream. The dam has a free spillway, main control gates and a bottom discharge valve.

When generating, the water flowing through the shafts from the upper reservoir is discharged from the machines in the machine hall into the surge chamber. The water flows from the surge chamber through a 3,200 ft. long tailrace tunnel to end in a large screened forebay on the shore of Loch Awe. The system is as shown in Fig. 4 (A and B).

When the station is pumping the direction of the rotation of the machines is reversed to lift water from Loch Awe to the high level reservoir.

The Inverawe station is a self-contained development. Its generator is driven by Kaplan turbine.Water from Loch Awe is diverted at a barrage in the Pass of Brander and passed through a tunnel to generate electricity at a power station near the mouth of River Awe. The Awe barrage is a concrete type structure, 287 ft. long and 59 ft. high. The barrage has two radial flood gates, a freshet gate, a Borland fish lift and two generators which produce electricity as compensation water is released down the river, in the interest of fisheries. An electric fish screen across the outfall from the station prevents salmon from entering the draft tubes and leads them along the river channel.

The Nant is also a self contained development. It provides additional storage for Inverawe power station. To supplement the natural flow of water to Loch Nant, a system of aqueducts were built to divert other streams thus doubling its natural catchment area. Compensation water is released to River Nant during dry periods.

No matter the type of installation, hydroelectric development has some adverse effects particularly to migratory fish.

By the establishment of barrage or dam an obstruction is

(A)

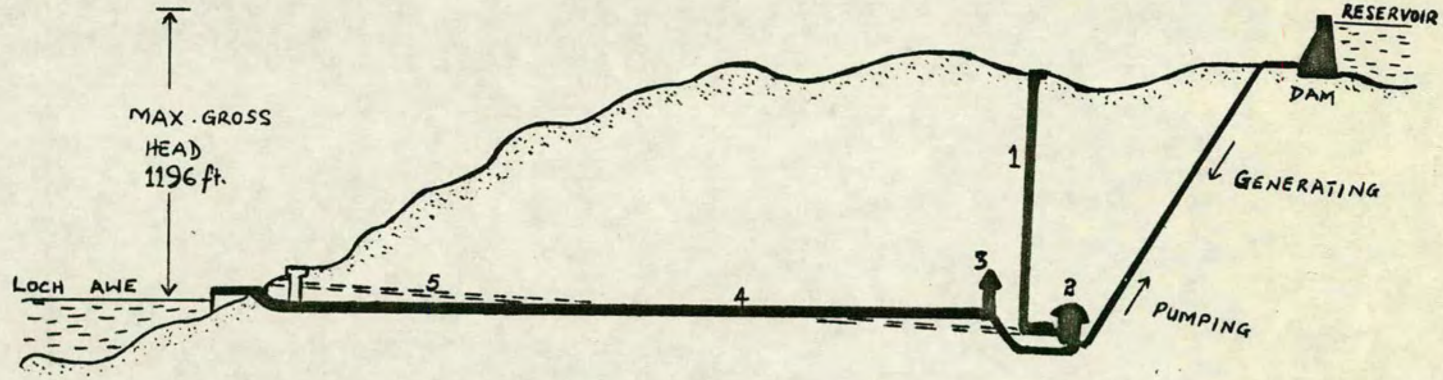
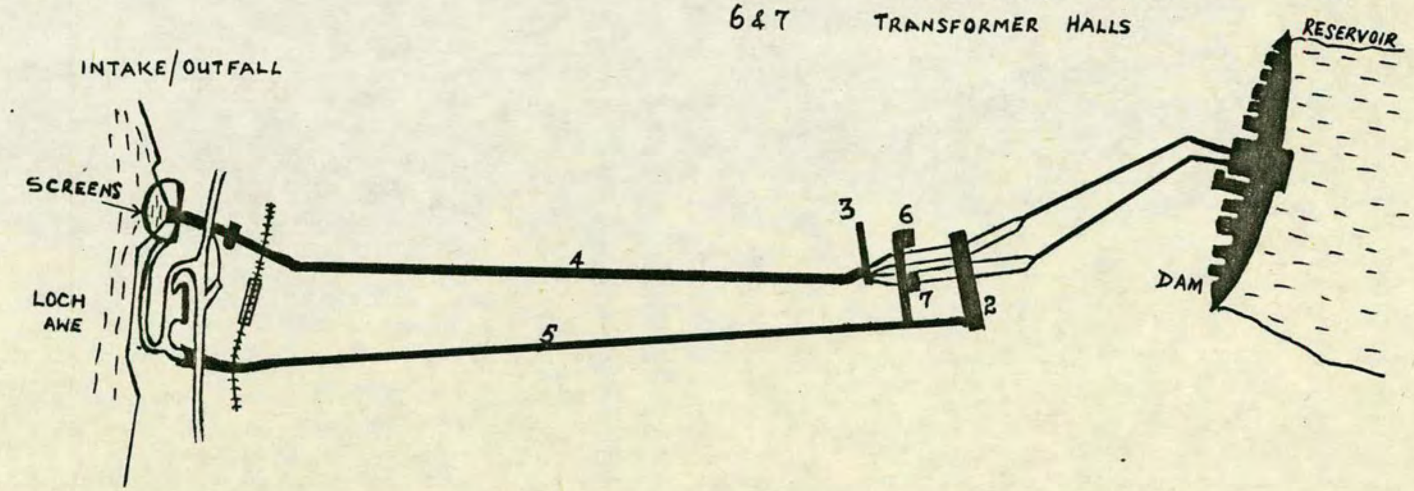


Fig. 4.(A&B) Awe Hydroelectric Scheme (Cruachan Dam and intake/outfall at Loch Awe only).

1 CABLE & VENT SHAFT
2 MACHINE HALL
3 SURGE CHAMBER
4 TAILRACE TUNNEL
5 ACCESS ROAD TUNNEL
6&7 TRANSFORMER HALLS

(B)



created across the water. The movement made by many fish during their migratory life cycle either for spawning or feeding is hindered. The delay in migration created for the upstream migrant is not only caused by the physical obstruction of the dam but also the low water downstream due to the impoundment. Because of this low water, there are possibilities for pollution and rise in temperature thus making the downstream water still more unsuitable. The homing instinct, to parent rivers by smell, Hasler & Wisby (Mills 1971) may be impaired due to water mixing in the impoundment.

Water diversion above the reservoir to make up the catchment area as in Cruachan & Nant and in other places where reservoirs are developed for hydroelectricity can adversely affect fish stocks by reducing suitable areas for spawning and rearing. Furthermore fishing activities are impaired and riperian owners may sustain economic loss. The natural contour of the terrain is changed and this at large could affect wild life.

Where passage e.g. fish pass is established, there may still be some delay in migration. If delay occurs, the migratory urge which lasts a limited period may wane and migration will cease (Pyefinch, 1966). The final spawning efficiency and natural recruitment after passage through the reservoir and flooded spawning grounds would be difficult to predict.

The downstream migrants (kelts, parr and smolts) face some hazards in the reservoir above the dam. The greatest threat is from predators. Losses in fish stock are often sustained due to predatory birds and fish. Mills (1964) noted that about 3.0% of the Atlantic salmon dry planted in the upper River Bran of the Conon River System reached the lower river as smolts. The losses occurred as these migrants passed through impoundments containing pike and brown trout.

Despite the screening of the tunnel intakes on Scottish hydroelectric schemes to prevent smolts and parr going into the turbines, it has been reported that substantial loss of fish stock still do occur due to damage by turbines. Mortality of smolts passing through the turbines at Clunie Power Station on the River Tummel was about 25% under normal operating conditions and at Invergarry Power Station where Kaplan turbines are used, it could be as high as 60% when turbines are running but providing no electricity and less than 20% when working under normal condition, Munro (Mills 1971). Apart from physical damage by runner vanes in the turbines, water speed, turbulence and pressure are likely to cause injury to fish.

Changes in water quality due to mixing are sufficient to influence fish life in the reservoir. Where smolts spend a further year in the reservoir because of inability to find the pass, heavy mortality could occur due to the impairment of the osmotic capacity in freshwater at the time of transformation from parr to smolt, Koch et al (Mills, 1971).

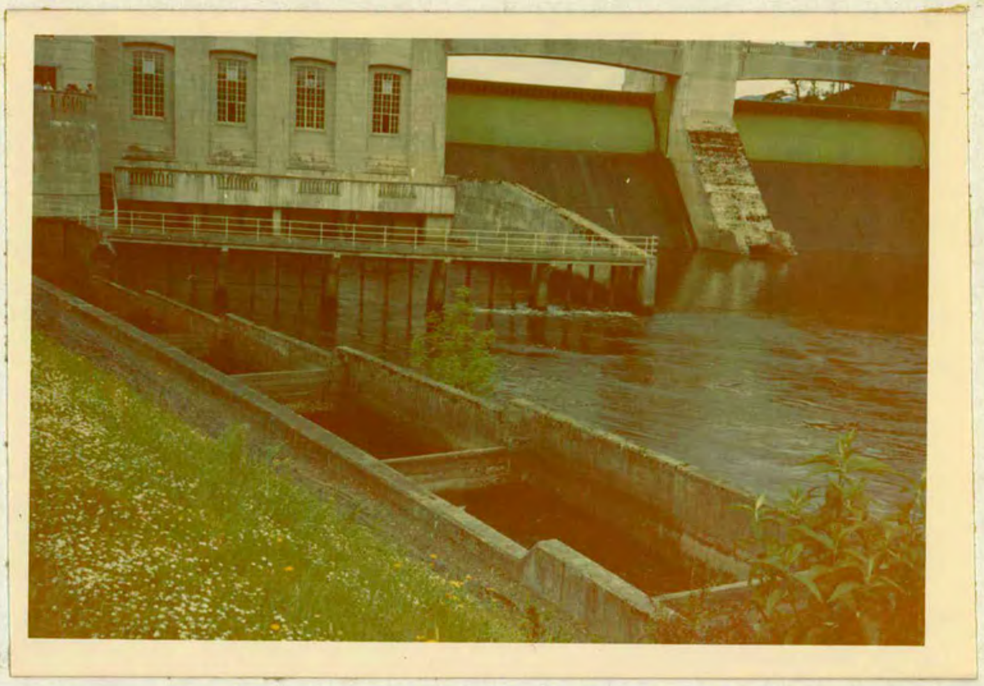
Usually large spawning and nursery areas are either reduced or eliminated by reservoirs, and fluctuations in water level below the power house could also result in exposure of redds and damage to fisheries downstream.

Physical changes in the environment are also brought about by hydroelectric dams. The contour of the river is affected. The natural gradient between the source of the river and mouth is disrupted. The flow regime of the river is affected and possibly giving rise to temperature fluctuations. Flood and drought conditions which affect fish movement and life in the water generally cease to show up as before. The water flow becomes fairly uniform, more because of negotiations between Hydroelectric Board Authorities and fishery Boards, on the volume of water for compensation to be released downstream. The compensation water may vary according to season as in the River Meig, one of the tributaries of the Conon River System where 37 cusecs of water is released from mid March to mid October and 9 cusecs is released from mid October to mid March (Pyefinch 1966).

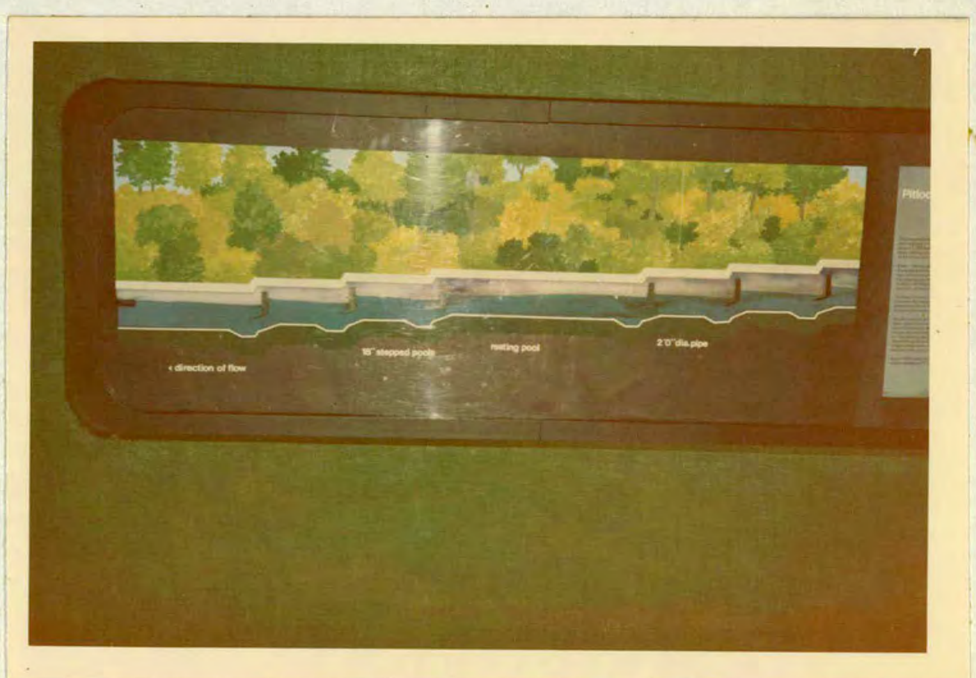
The change in the ecosystem of the river, is a function of the change in water volume and level, and physical and chemical nature of the newly formed water bed. This change will either give rise to rapid disappearance of certain species of aquatic fauna and flora or will result in the formation of new colony of life.

In view of the obstruction caused by hydroelectric dams, there is often the need to provide some means of passage for migratory fish. Provision of passage for migratory fish in salmon rivers where hydroelectric dams are constructed, is a statutory obligation for the North of Scotland Hydroelectric Board (Chapter 5.5). This demand will help to mitigate the adverse consequences of obstructions on fisheries. To this end a fish pass or fish lift is built into hydroelectric dams to allow movement of fish across the dam. In the Conon Valley Scheme (Fig. 5), Borland fish lifts are built into the Torr Achility, Luichart, Meig and Orrin dams. In the Tummel Valley Scheme, the Pitlochry Dam has a fish pass of a pool type, known as a fish ladder, (Plate 2). Types and basic principles of fish passes are discussed in Chapter 4.1.1.

PLATE 2.



A part of the Pitlochry Hydroelectric Dam Fishladder showing the connected pools design.



A side-view of a Fishladder model on display to show the succession of pools.

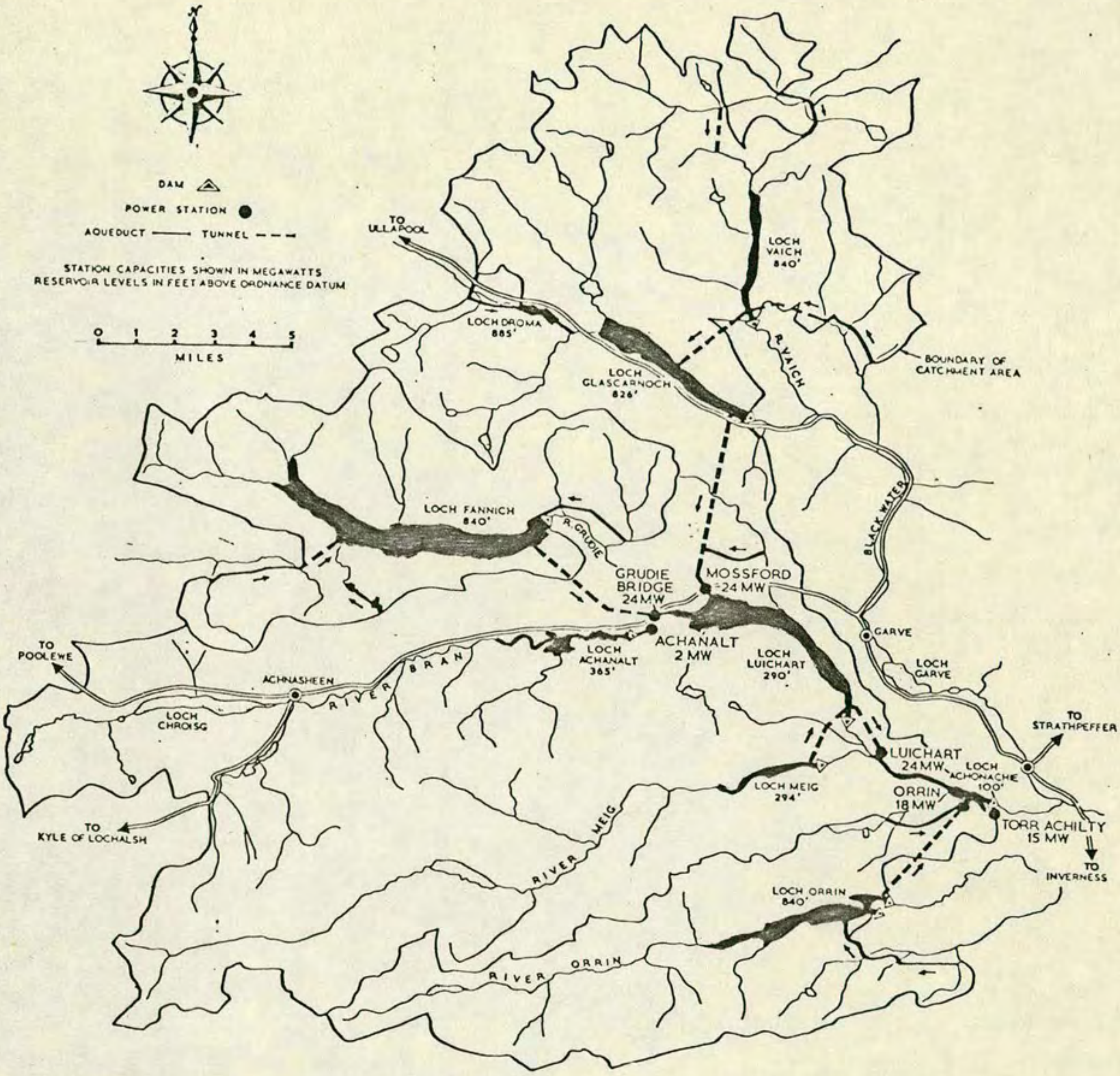


Fig. 5. Conon Valley Hydroelectric Scheme, Scotland.

(North of Scotland Hydroelectric Board, 1963, Report).

Salmon ascending rivers have to be prevented from entering tailraces of generating stations where they might be trapped or delayed. To avoid this, fixed mechanical screens have long been used. Recently the use of electric screens have been tried but have not proved to be any better. These electric screens work on much the same principle to that of an electric stock fence but it requires to have an uninterrupted supply of electricity. The electric screens set up a field which repels salmon and prevents them from getting into the vicinity of the generating turbines.

At times the establishment of a fish pass may be impracticable or uneconomic. Also the pass established may not be satisfactory enough to provide for quick and easy movement of fish. Under the circumstances, it becomes necessary to compensate for the loss of access to the spawning grounds by providing facilities for trapping the adult salmon, carrying out artificial fertilization (Chapter 4.1.2) and rearing the progeny if possible to smolt stage. The Fishery Boards in charge of the areas where the hydroelectric dams are built, carry out this exercise of trapping and stripping of salmon for hatching. Usually some hydrodams have hatcheries built into them and these hatcheries belong to the Fishery Boards of the areas. A number of trappings and strippings have been done by Fishery Boards and an account of this is given in Chapter 4.1.2.

In some cases an attempt may be made to collect by a trapping system the downstream moving smolts and parr from a point above the dam and transport them to a point where they can get to the sea without further obstructions. This is a more radical way of eliminating the difficulties caused by hydroelectric developments on the way of sea going smolts. Where physical conditions allow, this method could serve very well. The transporting of down-stream migrants (smolts) has been done with some success (Mills, 1966) and (Mills and Shackley 1971). The number of smolts transported, from the lower reaches of River Bran to a point below all the dams of River Conon System, ranged from 180 in 1964 to 9,090 in 1966 and percentage recapture of adult fish, tagged as smolts, ranged from 2.2 - 4.0 (Mills, 1966). Transportation of kelts in Scottish waters has also been done with some encouraging results. About 280 fish were transported, a distance of 55 miles, from Loch Poulary on the upper reaches of the Garry to the mouth of the River Ness. Some of these were recaptured upstream in Loch Ness and even in the Garry (Mills 1971).

In the face of difficulties and above demands cannot be met, it may become necessary to eliminate or terminate the fisheries problem by writing off the fisheries through financial compensation to the rightful owners. But quite often, economic, political and amenity considerations might render such proposals unacceptable.

The situation in England is far less of a problem than it is in Scotland, for fossil fuel is the main source of energy supply.

Like most African countries, fossil fuel for energy supply is still the main source. Hydroelectric development where it exists might not necessarily pose a fishery problem because of the lacustrine habitat most tropical fish are used to. In this instance, reservoir fisheries (Chapter 4.2.1) may be favoured.

The extreme development of hydroelectric dams on Swedish salmon rivers has virtually rendered these rivers, from source to mouth, unavailable to salmon. Because of these series of impoundments on rivers for hydroelectricity, natural recruitment of juvenile salmon has been greatly disrupted. The salmon stocks of many of the major salmon rivers, which have been almost entirely converted into a series of impoundments, are being maintained by a number of smolt rearing stations scattered up and down the country. In the Swedish situation the provision of a fish pass is almost impracticable and uneconomic because of the number of dams on a salmon river, therefore trapping and stripping of adults for artificial fertilization and propagation has become the only reasonable way of maintaining the stock of Swedish salmon. Despite the uncertainty of this process (judged on the basis of the numbers of the adults which return from releases of hatchery reared smolts), Sweden has no other alternative.

3.4 ILLEGAL FISHING METHODS

Although many fish are lost through natural causes, further loss is sustained through illegal fishing. Salmon and freshwater fish in the United Kingdom enjoy some statutory protection through the Salmon and Freshwater Fisheries Acts and fisheries regulations. The Acts and regulations not only defined fishing areas, times and methods but banned the use of certain methods e.g. explosives, poisons, traps gill, drift and some other forms of nets in taking salmon. Only rod and line and net and coble are allowed in inland waters.

Since the legislation of the last century, the commercial salmon crop in Scotland has been taken mainly in two ways; by net and coble (sweep net) in inland waters and fixed engines (bag and stake nets) on the coast outwith defined estuary limits. Few other methods like the use of haaf nets and poke nets which do not make a significant contribution to the total catch are used on the Solway.

The development of a gill net fishery to compete with the traditional fixed engines outside the estuary limits raised some problems because of its set backs and disadvantages. Gill nets like drift nets work by enmeshing the fish when they strike the almost invisible wall of monofilament netting. The only difference being that the gill net is anchored at both ends while the drift net is allowed to drift in the tide of the open sea. When the gill net was operated in Scotland, it was only legal when one end of it was attached to the shore where the operator had the salmon fishing rights, while the other end is moored to the sea bottom.

Research findings indicate that about 40% of the fish enmeshed in gill nets are lost through 'drop out' - which is one of the major disadvantages. The gill nets cause damage to fish thus leading to infection. Gill net areas are often an attraction to predators (The Salmon Net, X, 1975). The gill net is also known for its selectivity which can threaten the existence of a size or age class of fish species. It is therefore not unlikely that a persistent use of this gear on waters that hold a commercial stock of fish could be disastrous. In support of the ban of gill net in Scottish waters, because of its inherent problems an anonymous writer (The Salmon Net X, 1975) said:

> "The gill net threatens to upset the delicate balance between catch and escapement, between nets and rods, between a flourishing industry and a bankrupt disaster. It may well bring about the end of salmon rivers as we know them and the sport fishery they support. In each generation a challenge has come to our salmon and men have stood up and taken action that they deemed necessary for the long term preservation of our salmon. Let us all join together with one voice and call for the abolition of gill netting for salmon in Scotland".

On the Scottish coast, the principal fixed engines allowed, are the bag nets and stake (fly nets and 'jumpers') nets. The bag nets are used on rocky coasts and are floating. Each consists essentially of a trap made of netting to which fish are directed by a leader i.e. a line of netting placed across the route salmon usually follow as they move along the coast in their journey to the river. The stake net, plate 3, is used on sandy shores and consists of walls of netting,erected on stakes in the sea-bed,which acts as leader to approaching salmon.

The whammel net used previously on the Scottish side of Solway Firth is now illegal. The steel cairn nets and cruives used before in rivers and on the coast are also illegal now.

In England and Wales, bag and stake nets are forbidden. One type of fixed engine used on the Northumberland coast is the T net. Its advantage over the Scottish Stake and bag nets is its portability. The net is also frequently moved inshore as the tide advances.

A number of legal actions have been taken against individuals involved in illegal fishing and the use of illegal methods in fishing. In the Yorkshire Water Authority area alone, between 1972-1973, about forty-nine offenders relating to sixty-eight offences, ranging from poaching, use of unlicensed rods and nets, fishing during close seasons and times to aiding and abetting offenders, were prosecuted. In addition, riperian owners took two cases jointly with the Yorkshire Water Authority under the Theft Act which resulted in the payment of fines by offenders.

The drift net used to be the principal method of fishing for herring in Scotland. The drift net consists of sections of netting about 10 ft. in depth or more, suspended from a corked head rope and the net either weighted lightly at the bottom or allowed to sink gradually. Each net can be as long as 100 yds. and the nets are often joined together to form a much longer length of netting.

PLATE 3. Stake net as it is set on the Scottish coast.

The use of the drift net was rare for salmon. But as the herring and white fish stocks became depleted some of the commercial fishermen turned to salmon and drift netting technique developed fast off the east coast of Scotland.

Not until the Prohibition Order came into effect in 1962 was the use of drift net for salmon banned. This Prohibition Order came into effect as a result of a report of the Special Commissioners for Tweed Fisheries in 1875 and the Royal Commission on the Tweed Fisheries in 1896. The reports indicated that the drift net was among the types of gear used by sea fishermen in taking salmon in the Tweed waters. It was then in 1900 that the House of Lords declared drift nets illegal in the Tweed waters. In 1962 the Prohibition Order banning the use of drift net outside the 3-mile limit of Scottish Coast came into effect.

Unlike the position in Scottish waters, drift netting is legal on English waters i.e. 3-miles outsides the estuary limit. The nets which are either mono or polyfilament are shot from the boat across the current and allowed to drift freely. One end of the net is attached to a floating buoy and the other end is fixed to the boat. The top rope is corked to allow floating while the foot rope is leaded to keep the net upright. These drift nets are still used today in the Bristol Channel, the Ribble and Lune estuaries, the Solway and seven miles off the south of the River Tweed (reference Tweed Fisheries (Amendment) Act 1859).

Because drift netting is allowed by the English Laws, the Northumbrian sea fishermen engage in this practice which is having an effect on the Scottish salmon. Though this is a legitimate act on the part of the English and provides employment for about 500 English sea fishermen (Champion (North Water Authority), personal communication), to the Scottish it is illegal and nothing can be done about it unless the English Law is revised to stop drift netting for salmon.

Drift netting by the Northumbrian sea fishermen has contributed to the decline in salmon and grilse run in the North Esk Fishery Board area. By the end of the season i.e. 1976, about 25% of the total grilse run had been creamed off by the illegal drift netters (N. Esk Fishery Board Ann. Report 1976). The attitude of the English drift netters was attributed to the foreign depredations on the fish stock in the English waters, the abundance of salmon stock in August which tempted the white fishermen and failure of Scotland to protect her waters beyond the 3-mile limit. The protection of the Scottish salmon and fish stock within the 3-mile limit is the responsibility of the District Salmon Fishery Boards and beyond the 3-mile limit, it becomes the responsibility of Secretary of State to protect the waters from foreign depredators and illegal fishing. On the strength of the English drift netting, low percentage return (1.77%) of tagged wild smolts was recorded in August 1976 when compared with previous returns (N. Esk Fishery Board Ann. Report 1976).

Poaching incidents are not ruled out in some Scottish waters and even in privately owned fisheries where the private owners can only exercise their rights under the Common Law to protect their fisheries. An attempt was made to net Morphie Dyke in December 1975 in the North Esk Fishery Board area. The net fouled the anti poaching devices and this was discovered by bailiffs. The Burn in North Esk Fishery Board area was successfully raided by use of poison. Through investigations and examinations of remaining dead fish by the Freshwater Fisheries Laboratory, Pitlochry, fish death by use of cyanide was confirmed.

In a tropical country like Nigeria, as periods of heavy inundations afford a measure of protection to the fish at spawning time so too the dry season provides an ideal fishing period for native fishermen. Fishing communities take advantage of the low water level. They travel several miles, pitch their huts along the river banks, exploit the resources and pay royalty where it can't be avoided to the clans holding fishing rights over the area.

In such instances fisheries are regarded as 'common property' resources and are open to exploitation by all. The fishermen though realising the dangers of such an exploitation, could not apply self-restraint which might be to the advantage of fellow fishermen. Since each fisherman is bound by this reasoning, stock depletion will continue to increase. This is the problem of common property described by Hardin (1968) as the 'Tragedy of the Commons'. He noted:

> "As humanity seeks to wrest food from the water, species after species of aquatic animals approach extinction. Since the beginning of this decade the gross harvest of fish has fallen - an indication that the fish resource is being exploited beyond its point of maximum sustainable yield. Man's response has been to try harder an action more suicidal than sapient......"

Different fishing equipment ranging from spears, traps and nets of all sorts to explosives and poison are freely used, irrespective of the season. The larger the common resource the more diverse its exploiters and their methods particularly in countries where fisheries legislation is weak or non-existent. To the fishermen, there is nothing illegal in their method to exploit the fishery resources of the water as long as they fish within their rightful zone of the water.

Welman (1948) out of disgust for this uncontrolled method of fishing, narrated the result of his investigation on one large tributary of River Niger - Nigeria:

> "On investigation I found that fishing rights had been leased out to a party of Wudilawa (a fishing tribe) who were encamped on the river. I watched some of these fishermen at work. They were dragging a large pool with a sixty-foot seine net having a mesh of about 5 inches. After several good hauls, they continued dragging until the net ceased to catch. Two smaller finer meshed nets were then brought into operation and finally several long shallow nets of which the mesh was certainly less than one inch. At the end, the fishermen had covered the whole of their five-mile beat leaving behind them a string of pools from which practically all sizeable fish and most of the immature ones had been cleaned out".

Pool draining and blocking of water inlets is not only harmful to fish but also disrupts the fish habitat. Aquatic plants are exposed to the air during hot weather. Fish eggs attached to plants are exposed to dessication, fry and fingerling are lost and fish food is adversely affected. A general loss of fish and fish food is sustained.

Use of poison and explosives is also disastrous. The poison extract from shrubs like *Trephosia vogelii* and *Mundulea sericea* used by natives kill fish indiscriminately. The active principal of *T. vogelii* is tephrosine ($C_{23}H_{22}O_7$) and the active ingredient of *Mundulea sericea* is mundulone ($C_{26}H_{26}O_6$). These are closely related, chemically and in their action to the fish poison - rotenone ($C_{23}H_{22}O_6$). Tephrosine and mundulone affect respiration and are fatal to fish in small concentrations. They are not toxic to man and do not affect the fish as food.

The mash of these plants is applied to enclosed waters and stirred. In general, the fishermen use stronger concentrations than necessary e.g. concentrations as high as 1lb per 10 cubic feet are applied. Because of this, their effect is rapid and fish are found circling on the surface of the water from 5-10 minutes after introduction of the poison. A total fish kill can occur in one hour or two, depending on the concentration of the poison.

Other poisons e.g. insecticides like, "gammalin 20" are also used for fishing. This insecticide is used commonly in Nigeria for the treatment of blackpod disease of cocoa. This chemical is very lethal, affecting all the fauna in the water where it is introduced.

Although the fishermen know the consequences of this method of fishing, their action has stemmed more from their poor financial state to provide for the conventional and less injurious means of fishing and the dire desire to grab as much as possible of the 'common property'.

3.5 DISEASE AND PREDATION

DISEASE:

Under natural conditions fish seldom suffer from any severe disease outbreaks though the ulcerative dermal necrosis (UDN) which broke out in the 1960's in some Irish and Scottish waters was fatal to salmon. However the potentials for severe outbreaks of disease exist when fish are crowded together whether in the wild or being reared under artificial conditions.

A disease outbreak in a river system can spread to other rivers. Salmon disease broke out in Border Esk and Nith Rivers in autumn and spring 1877 and by 1880 to 1882, it had spread to the River Tweed, rivers in S.W. Scotland, North Wales, Tay and North Esk in Scotland. Similarly ulcerative dermal necrosis broke out in a number of rivers in S.W. Ireland between 1964 and 1965. By 1966 it got to river systems in Lancashire, Cumberland and Solway. In 1967 and 1968 it covered most East Coast Rivers - Tweed and Nairn in Scotland, Solway, Rivers on the West Coast and the river systems of the Tay, Forth and Conon in Scotland. Elson (Mills 1971) suggested that sea trout might be responsible for the spread of UDN since they move from estuary to estuary.

Since the UDN, no serious disease outbreak fatal to fish stock has occurred in the United Kingdom. Although death of fish, due to disease, do occur occasionally, it is within reasonable bounds. At times fish death occur due to the complex situation aggravated by pollution (Chapter 3.1).

Farming of fish and introduction of new species like the proposed introduction of Coho in Scotland could aggravate the spread of fish diseases. In reared condition greater chances of infection because of crowding exist, though there is the advantage of more effective prophylactic and chemotherapeutic treatment than in the wild. An escape of diseased fish from the reared environment into the wild could well be a threat to the fish in the wild hence the big outcry against the introduction of Coho for rearing in the farms because of the deadly disease, viral haemorrhagic septicaemia (VHS) commonly associated with it.

Certain diseases are known to be associated with certain groups of fish. For example, ulcerative dermal necrosis is a viral disease of adult salmon and is favoured by low temperature. Furunculosis which is bacterial is associated with the salmonids. It is favoured by high temperature (13°C and above) and low water level. Other diseases associated with the salmonids are viral haemorrhagic septicaemia (VHS), Infectious pancreatic necrosis (IPN) and salmon disease which has the pattern of UDN but very rare and only occurred in the late 1880's in Scotland.

The channel catfish which is a sport fish in U.S.A. is usually associated with the channel catfish viral disease (CCVD), while the cyprinids usually suffer from swim bladder infection (SBI) which is viral and infectious dropsy of carp (IDC) which is bacterial. Both diseases are favoured by high temperature and the latter is favoured more by the presence of organic substances in the water.

Fungal attack generally occurring is secondary as a result of skin abrasion which is common among fish in crowded conditions. Because of similarity of symptoms of fish diseases (particularly of the salmonids), infected fish exhibit a syndrome which is difficult to diagnose. This makes treatment hard until the aetiological agent is isolated and identified.

Fish parasites are also many and can be wide spread. For example, twenty-three species of parasites (Protozoa, Cestoda, Trematoda, Nematoda, Acanthocephala and Mollusca) were recorded from trout, perch, pike, stickleback and minnow in Loch Leven alone (Campbell, 1972/73) and despite this number, no significant deaths resulting from their infection have been observed. Loch Leven, Kinross in Scotland is known for the brown trout it supports and anglers and visitors take interest in fishing for the trout for its quality. But the presence of the tapeworm Eubothrium crassum, in brown trout in the loch has helped to make it distasteful and unsightly and undoubtedly could suppress an angler's interest in taking brown trout in the loch even though it is said that the worm causes no harm to the fish. This cestode parasite of salmonid fishes is found in the pyloric caeca and infection of trout is by ingestion (predation) of an intermediate fish host e.g. Gasterosteus aculeatus or a cyclopoid copepod carrying the infective stages, plerocercoids or plerocerciformes (Campbell, 1972/73).

There are incidences of eye fluke infections. Most of the rainbow trout netted from the moorland ponds at Meldon (see Appendix, Trip 2) were observed to be infected with Diplostomum spathaceum. Eye fluke infection though not on any significant scale has been observed at a rainbow trout farm at Inverary (Appendix, Trip 3).

There are also records of occurrence of Argulus sp. - fresh-water fish louse - in Scotland. Carphin, (Campbell 1971), found A. foliaceus on a stickleback in a canal (presumably Union Canal) near Edinburgh. Scott (1901) mentioned that A. foliaceus was plentiful for sometime on Grayling, Thymallus vulgaris in the upper waters of the River Clyde. Records of the Royal Scottish

Museum, Edinburgh, according to Campbell (1971), indicate that A. foliaceus has been found on bream - Abramis brama in Castle Loch, Lochmaben in 1954. Argulus coregoni has also been observed on some brown trout Salmo trutta in the River Clyde.

Sedgewick (1973) while discussing the treatment of common diseases of trout, noted that most diseases which occur in epidemic forms are attributable to domestication of the fish and the density at which they are kept when reared. Diagnosis and treatment of fish diseases demand the expert attention of trained personnel.

The use of chemotherapeutic agents e.g. sulphonamides, terramycin, chloramphenicol oxytetracycline and other antibiotics in the treatment of bacterial diseases like vibriosis caused by Vibrio anguillarium and related bacteria are known to develop some complications. They have resulted in drug resistant mutants and development of resistance transfer factors (R. factors). With these, the bacteria do not only resist but also pass the resistance (R. factors) to human pathogens. The treatment of Vibrio anguillarium has transferred the resistance to cholera organisms and the treatment of furunculosis (by use of antibiotics) has also transferred the resistance (R. factors) to typhoid organisms in Japan (Munn, 1976). This could well mean a threat in countries where human sewage effluent is used for fish breeding.

In the United Kingdom, strict compliance to the Diseases of Fish Act 1937 has helped to protect the stock of fish in inland waters. Pathological examination of fish is also carried out by fishery boards and water authorities to safeguard against the spread of fish diseases and parasites to uninfected waters with the movement of fish from one locality to another. The import of fish either for propagation (food production) or for ornamental purposes from sources outside one's country is a widespread and frequent practice. While importation from without the country helps to introduce fish diseases and parasites into the country, an internal movement of fish on the other hand provides an ideal opportunity for the spread of diseases and parasites. For example, the anchor worm, *Lernea cyprinacea* which spread to Bradford and Essex localities in the U.K. was suspected to have been imported with goldfish from Italy (Kennedy, 1975). The movement of freshwater fish (bream and tench) from Stambridge, U.K. to Howbrook Reservoir, led to the spread of crustacean fish parasite *Ergasilus sieboldi* which heavily infected twelve brown trout in the reservoir and resulted in their death (Kennedy, 1975). The parasite has also been found in the River Blackwater, Essex, having undoubtedly escaped to there from Stambridge. *Ergasilus sieboldi* has also been found on chub in the River Stour and it seems probable that it spread to there from the nearby River Blackwater as a result of movement and distribution of fish from one river to another.

It is not often possible to record the economic losses due to disease in migrating wildlife species such as the salmon - *Salmo salar*. Inconsistencies in the geographical pattern of disease spread can contribute to improper assessment of losses. Also complication caused by the presence of fungus can bedevil reliable assessment of mortality caused by a particular disease. However the number of salmon and grilse infected by ulcerative dermal necrosis and removed from Scottish rivers, Fig. 6, between March 1967 and February 1968 was about 41,234 (Mills, 1971). This is about 12.6% of Scottish catch for 1967. As much as 6000 salmon infected with salmon disease were removed from the River Eden between 1878 and 1883.

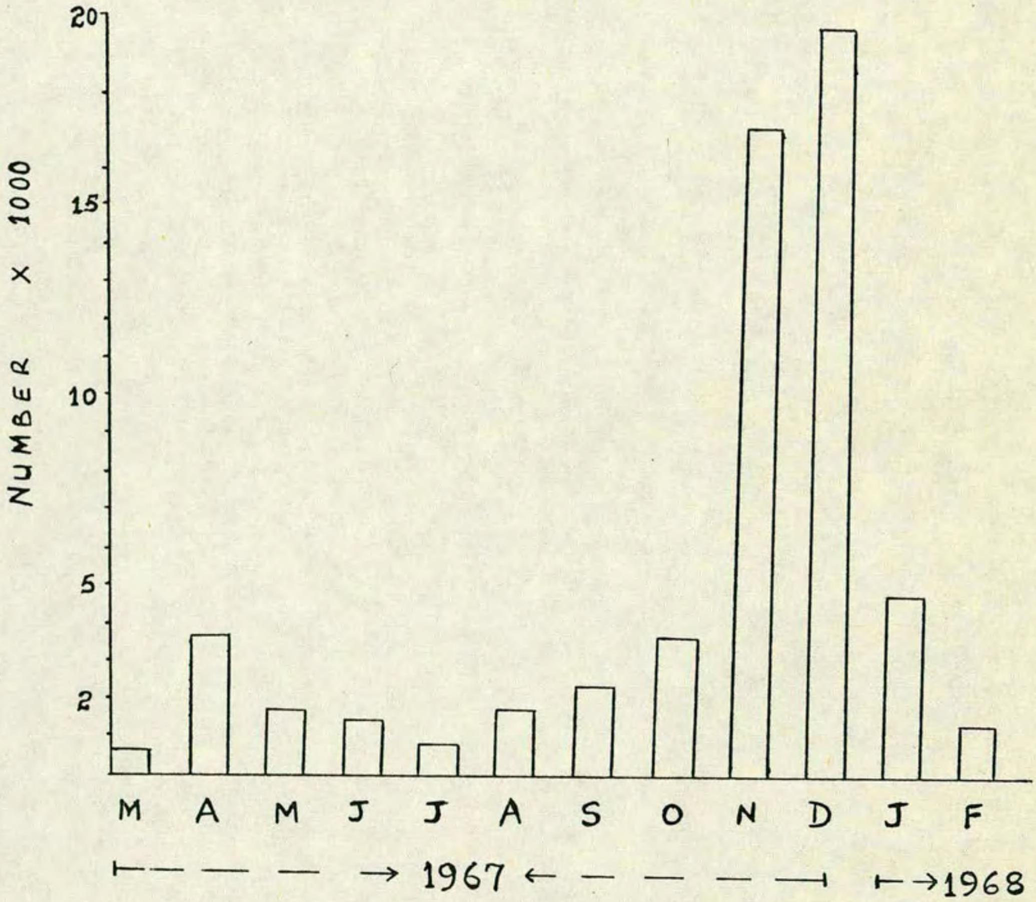


Fig. 6. Monthly numbers of diseased salmonid fish from Scottish rivers where U.D.N. is suspected of being the major contributory cause to disease. (Mills, 1971).

On the Scottish coast, incidence of parasitic nematode, Porrocaecum decipiens in cod has been recorded. This is due to the grey seals. Grey seals serve as final hosts to the parasitic nematode. Off the West Coast of Scotland nearly 40% of cod are affected and in the upper Firth of Clyde over 50%. Intermediate degrees of infestation occur within the Firth of Forth and in Moray Firth. The percentages of infested fish are correlated to the numbers of seals in various areas (Rae, 1960). The parasites have helped to reduce the market quality of cod and the thirst for it amongst housewives. Its overall market value seems shaken and it tends to loose its competing power in market prices when compared with other marine fishes such as haddock and lemon sole.

Severe financial loss is suffered by commercial fisheries owners through disease and parasite outbreak. In the inland waters, angling-based tourism is affected and the money accruing from sales of licences for sport fishing is also lost. Short supplies of fish result thus being short of consumer demand. Because of the scarcity and high demand, market prices of fish jump thus affecting consumers and fish rearers who would like to purchase their stock from disease free areas.

PREDATION:

All animals including fish are subject to predation. It is not always easy to establish the predator-prey relationship or to assess critically the value of predation in fishery management. However many authorities like Elson (1962), Mills (1962 and 1964), Lockie (1962), Rae (1968), White (1936 and 1939) and Ricker (Mills 1967a) through investigations and experiments have estimated the daily and annual consumption of fish by predators and the overall effect of predation in fisheries.

White, (1936) estimated the number of fish consumed by kingfishers on 30 miles of stream on the North east Margaree River, Nova Scotia to be 330,000 young salmon, 50,000 trout and 40,000 other fish. He based his estimation on the mean daily food intake which is used to calculate the total number of fish consumed in a particular area. Basing his calculations on an average weight of salmon parr of 9 gm, White (Mills 1967a) estimated that it took 32 kg of fish (15 kg - young salmon and 15 kg - 1584 salmon parr) to rear one American merganser to full growth and that on this basis, 1200 American mergansers shot on the Miramichi River represent an annual consumption of over 1.9 million salmon parr. Using the weights of 'meals' either found in the animals at the time of examination, or the size of 'meals' known to have been taken over a certain period, should be cautiously relied on in long term estimates since these were short period observations and depended on the number of predators killed or the rough estimate of the number of predators in the area (Mills 1967a). However with strict census of predator population as with the crested grebes of England and Wales, their fish consumption in 1931 was calculated to be 900,000 lbs. On this basis, Prest and Mills (Mills 1967a) could show that with their increase in population, their fish consumption rose to 1.3 million lbs.

Several studies have been done to give general information on the habits of fish eating animals. The studies which covered the classes of the animal kingdom had also been carried out with the purpose of discovering if certain animals were likely to have predatory effects on stocks of fresh water fish and possibly to determine their importance. Predators are usually blamed by individuals and fishing communities as being responsible for losses in fish stock and occasional economic losses. The animals taking much of the blame are the predatory birds, some of which are the heron, cormorant, various species of gull, American merganser, red-breasted merganser, shag and belted kingfisher. The mink, otter and grey seal are also said to contribute to fish losses. As for the predatory fish, it is not always easy to determine the extent of their predatory behaviour unless in controlled environment.

Occasionally evidence has shown that the suspected predators do not constitute a threat to fish stock. The reason for this could be biological or geographical or both. Cott (Mills 1967a) found that two species of cormorant Phalacrocorax lucidus and P. africanus were not harmful to the fisheries of Lake Victoria, Africa. In the same way, some animals found to be serious predators on fish of economic importance may vary in their predatory behaviour from area to area. On the strength of this, predator control in one area might not always be biologically justified elsewhere. (PREDATOR CONTROL IS SEPARATELY TREATED IN CHAPTER 4.1.3). For example the goosander was found to be a serious predator of young salmon in some Northern Scottish rivers

(Mills, 1962) but Madsen (Mills, 1967a) considered that it did little or no harm in Denmark as it ate mainly cyprinoids, though to some extent it was found harmful to eel fishery. The American merganser was considered a serious predator on young Atlantic salmon in Eastern Canada while it did not affect Pacific Salmon, Oncorhynchus sp. in Western Canada. Similarly the black headed gulls are considered serious predators of salmon fry on the River Ness and on the River Bran during prolonged low water and sunny conditions only (Mills, 1967a). As can be seen, considerable work on predation has been done in Scotland and Canada, but control of predators (Chapter 4.1.3) in Scotland is not part of real management.

Predation, on important commercial and sport fish, by birds in Scotland has further been established. From the study of the food of cormorants in Scottish inland waters, Mills (1965) revealed that in freshwater lochs, cormorants feed mainly on Brown trout (42.8%), perch (38.1%) and salmon (19.0%) and to much less extent on common eels, sea-trout and insects. In the Scottish rivers, the commonest items in the cormorant food are brown trout (22.6%), flounders (22.6%) salmon (17.0%), common eels (13.2%), sea-trout (5.6%), sticklebacks (3.7%), pike (3.7%) and gadoids (1.9%). Investigations (Rae,1969) have shown that the food of cormorants and shags in the estuaries of the rivers Dee, North and South Esk and on the adjacent coasts consists predominantly of fish. Table 12 gives the percentage of each (cormorant and shag) feeding on the principal food types in each locality. More cormorants feed on flat fishes, gadoids etc. in contrary to what it is in the inland waters and rivers. It clearly indicates the function of the locality in predators' choice of food.

Table 12

Percentages of Cormorants and Shags feeding on the principal food types in each locality : Rae (1969)

	CORMORANTS			SHAGS		
	DEE	N. & S. ESKS AND MONTROSE BASIN	COAST	DEE	N. & S. ESKS AND MONTROSE BASIN	COAST
FISH	98	100	100	100	100	97
Flat Fishes	40	58	29	30	-	1
Gadoids	43	11	26	60	-	14
Clupeoids	9	2	4	5	-	5
Salmonids	6	11	6	5	-	-
Shore Fishes	20	20	20	25	50	21
Common eel	8	2	1	5	-	-
Sand eel	2	2	3	5	-	29
CRUSTACEANS	6	4	7	10	8	14
MOLLUSCS	2	2	1	-	-	2

Seals: The seals are known predators of fish. The Atlantic or Grey seal - Halichoerus grypus and the common or brown seal are the two species of seal found in British waters. The seal population was almost wiped out due to over-exploitation by hunters and to avoid their extinction, total ban on seal hunting was imposed in 1932. The ban on seal hunting resulted in their population explosion. By 1974 grey seals in British waters numbered about 40,000 and it is estimated that this number requires about 100,000 tons of fish annually (The Salmon Net X, 1975).

The Grey seals though feed on fish of commercial importance, are not very selective for they tend to eat whatever fish that is available. They usually tend to congregate in estuaries where salmon have concentrated before entering freshwater, and where they rob the nets of their catches.

Analysis of stomach content of grey seals from the Scottish mainland showed that fish and fish remains were identified in 90% of the stomachs containing recognisable food. Two families of fishes were of frequent occurrence in the food. These were the salmonidae (30%) and the Gadidae (47%). Among the individual species of fish preyed upon, salmon was 26%, and cod 22%. Three other gadoids; saithe, whiting and haddock were each eaten fairly frequently by 4-10% of the seals (Rae, 1968).

In addition to fish, grey seals also ate various types of molluscs (squid and octopus) and crustaceans (crabs). About 15% and 13% of the stomach examined by Rae (1968) contained molluscs and crustaceans respectively. These compared with the fish make up a small ratio of the food of grey seal.

The common seal which is confined more to relatively sheltered waters, would appear to prey heavily on gadoids (saithe and whiting) and to a lesser degree on salmon, flat fishes and clupeoids. In general, predation by seals is chiefly on those spp. of fish which are most readily available by reason of their numbers or their size and locality.

Damage by Seals: Damage to fish and fisheries can take different forms. The grey seals claw and mark fish thus resulting in their low market value or the fish may be killed and eaten resulting in total loss. Fish damage is widely encountered and the extent of damage depends on local circumstances and time of the year. It has already been estimated that about 80% of the seal population is based on the Scottish coasts. The quantity of fish eaten annually by all seals, based on Lockley's, Havinga's and Matthews estimates (Rae and Shearer 1965), is 80,000 tons yearly. Assuming that the quantity of fish eaten is in the same proportion to the population of seals, it means that about 65,000 tons of all kinds of fish are eaten by seals in Scottish waters every year. This is nearly one fourth of the total Scottish catch from home waters.

The loss sustained by net and coble fishermen in the mouth of the River Tweed from seal predation amounted to more than 2% (or may be as high as 7%) of the total salmonids (salmon, grilse and sea trout) catch (77,780 tons) from 1956-1958 and in 1960.

Joseph Johnston and Sons Ltd. of Montrose (visited during one of the series of field trips) - the largest salmon fishing firms in Scotland had 9.69% of their salmon in 1974 marked by seals. This quantity bitten or clawed by grey seals, is rendered valueless and the number of salmon killed (either eaten or completely destroyed and which could not be recorded) must be considerable, (person. communication).

From a study area, 48 km of Scottish and English coast, Lockie (1962) estimated that about 23,000 lbs. of salmon and sea trout were removed by 67 immature grey seals and young bulls during the 1957 salmon fishing season. This quantity is about 3% of the total commercial catch for the area.

On the basis of the number of seals seen by fishermen in the vicinity of the nets, Rae & Shearer (1965) estimated that 147,888 salmonids were killed by seals on the Scottish east coast between 1959-1963. The average monetory loss to the industry on the Scottish east coast is estimated at about £67,000.

It is recognised that marked or damaged fish fetch a lower price on the market. Prices however vary with the nature of the wound. Records of seal-marked salmon at or near the mouth of the River Tweed in 1954 reached totals of 810 and 933 fish and the loss was calculated in each case at about £400.

The grey seals interrupt and temporarily destroy fishing power and cause diversion of fish from the nets (Rae & Shearer, 1965).

Damage is done to fishing nets by grey seals. The amount of net damage varies from station to another and depends on seal distribution and activity in the area. In nearly half of the stations examined on the Scottish east coast, damage did not exceed 5% while in some stations it exceeded 25% (Rae & Shearer 1965). Damage is greater at stations where the whole fleet of nets and major part of it consists of bag nets.

Value of Predation: Quite often the harmful effects of predation tend to overshadow its benefits. While many talk of the harm caused by predators, few have given thought to the value of predators in fishery management.

Population Control: Predation helps to keep in check the population of some highly reproducing species of fish. Lates niloticus stocked with Tilapia sp. will feed on Tilapia sp. and probably help in controlling its population. Where fish are small and numerous e.g. trout in hill lochs in Scotland, and in the absence of predation and exploitation, the introduction of a predator would help to improve the stock of fish. Since the cormorants helped to keep in check the excessive population of perch, it has been suggested too that the birds would be useful to the trout stocks in Windermere, Macan & Worthington (Mills 1967a).

The feeding habits of fish are considered in polycultures. Trash fish that have high fecundity can be stocked to serve as food for the predatory fish of commerce.

Removal of other Predators: Predators besides eating fish of commercial importance also eat other predators of important fish spp. In the Great Lake of North America, Chinook and coho salmon were introduced to feed on alewives that increased in numbers after the sea-lamprey had almost wiped out the Great Lake Trout that used to feed on alewives. The commercial catch of chinook after a period of 1-2 years was high.

The American merganser (bird) feeds on eels and this is an advantage to the salmon fisheries because the eels are predators on salmon (Coldwell, 1939).

Although crocodiles (Crocodilus sp.) cause substantial harm to fisheries in the tropics by tearing the fish out of nets, they are also found to eat other fish eaters such as turtles and snakes.

Despite the difficulty in estimating the number of economically important fish that are eaten by 'top predators', Vladykov (Mills 1967a) estimated that the removal of 50,000 trout by kingfishers on the North east Margaree River, probably saved 500,000 salmon parr in 1935.

Removal of diseased and Parasitised fish: The otters are known to remove old salmon and trout infected by fungus and the Kodiak bear shows relationship to red salmon by utilizing the carcass of unspawned salmon which have died naturally, Clark (Mills 1967a). In serving as a scavenger the bear helps to preserve salmon runs and prevents fungus infestation. Diseased and parasitised fish are at a disadvantage. Because of their sluggish movement, they are always exposed to an attack even when moving in a shoal.

There are some circumstances where predators serve as hosts for fish parasites and under this condition spread of fish parasite is encouraged. In the moorland ponds at Meldon, Scotland, the black headed gulls which predate on the trout serve as the final hosts for the eye fluke - Diplostomum spathaceum. These birds have helped to spread the fluke with the result that many of the rainbow trout in the pond, became infected. With the control of the gulls by the disruption of their feeding and resting sites around the ponds, the incidence of eye blindness in trout in the moorland ponds was greatly reduced.

Similarly the grey seals contribute to the incidence of larval stages of the parasitic nematode - Porrocaecum decipiens in the flesh of cod and other marine fish. The percentages of infected fish show a close correlation with the numbers of seals in the various areas (Rae, 1960).

Predation on fish by animals (fish, crocodiles, otters, snakes, birds etc.) in tropical African inland waters, is significant and worth mentioning.

The most predatious fish are the Nile perch - Lates niloticus and the tiger fish - Hydrocyon vittatus. These fish are known to be present in most of the larger river systems such as the Nile, Niger, Volta, Congo, Zambesi and Limpopo. They also occur in most East African lakes e.g. Albert, Rudolf, Bangweulu and Tanganyika.

Lates niloticus is the biggest predatory fish in Nigerian inland waters and specimens of about 100 lbs. or more which inhabit the deep reaches of the River Niger are known to have been caught (Welman, 1948). It is also a threat to fishermen.

Hydrocyon vittatus is a fierce and voracious predator which swallows its fish prey, whole. It is not as big as Lates spp., has a mean length of 55 cm (while Lates spp. is about 120 cm) and a mean weight of 3 kg. For this the impact of predation is upon fish less than 40% of the predator's length (Jackson 1960).

Predation by these fish is not strictly on choice. It is rather dependent on the species of fish abundant and available to the predator. Varieties of fish have been found in the 184 stomachs of tiger fish examined (Jackson 1960). Because of the darting action of tiger fish, they are not used to inhabiting areas with dense vegetation. Fish preys therefore take advantage of this, and hide away under covers. The commonest fish prey of these predators are the cichlids, Alestes sp., the clarids and cyprinids and Barbus sp. All these species irrespective of their size and number contribute to food in tropical Africa. Most of the fish which form the food of these two big predators are themselves predators on smaller fish.

The impact of predation by Lates sp. and Hydrocyon sp. has a marked retarding influence on speciation of African fishes Worthington (Jackson 1960). He noted that speciation occurred mainly in those genera in lakes and species well removed from congeneric species, outside which have never known predation pressure from ferocious predators. He remarked "where predators are continually on the prowl, the lesser forms adapted to their particular ecological niches, can depart from them to colonise new micro environments or to breed with their neighbours only on pain of death". Although Worthington referred to Lates and Hydrocyon spp. there have been counter views to this personal opinion on the grounds of other factors which border on predator/ prey relationship. Such factors include size of prey, availability, evasive tactics and microhabitat of the prey.

The rate of predation of other animals (crocodiles, birds - particularly kingfishers, and snakes) on fish are yet to be established. Even though these predators take a good quantity of fish from the waters, the smaller predators are also preyed upon by bigger ones. For example, the crocodile predates on snakes and turtles which are fish predators. The small water snakes are also victims of fish eating birds.

When the effects of fish predation in Nigerian inland waters are established, the estimated number of fish taken daily might be staggering. This is a quantity lost as food to rural dwellers that greatly deserve fish protein.

3.6 AQUATIC PLANTS

Water invasion by plants (algae and vascular) in the United Kingdom is neither as prominent nor as a problem as it is in the tropics. Mud which generally occurs in most tropical waters and serves a good substrate for plants is not commonly present in burns and rivers in the U.K. However in some lochs and reservoirs in the U.K. plant growth and spread have occurred at a much faster rate than in other bodies of water. This is due to eutrophication and flushing-in of nutrients from the surrounding agricultural and industrial fields into the waters. Where eutrophic conditions exist and macrophytes and algae develop, there could be chances of low oxygen concentration in the water at summer nights resulting in fish mortality. Eutrophication and low water level in the Grafham reservoir in East Anglia caused a wide spread of algae bloom which caused low oxygen concentration. Fish mortality was also recorded. Changes in the environment led to the invasion of the reservoir by some coarse fish such as perch.

The spread of aquatic plants is also favoured by the summer temperature and its typical sunshine which help to reduce water level and encourage alga bloom. This situation can be harmful to fish stock. For example in the Tweed, the spread of Cladophora sp. at low river flows caused low oxygen concentration during the summer nights and resulted in high fish mortality.

Angling and netting efficiency is lowered by water plants. This was experienced during a field trip to the River Tweed. The netting operation carried out on a small pool - an off-shoot of the River Tweed was virtually disrupted because of dense growth of crowfoot and pond weeds. Alga bloom is known to foul anglers' lines and commercial nets as well.

Generally aquatic plants are usually of three types; filamentous algae, floating vascular plants and rooted emergent plants. The filamentous algae commonly occur in man-made lakes in the tropics and in the rivers affected by sewage and organic pollution. These algae include Spirogyra sp., Chara sp., Cladophora sp.,Ulothrix sp. and Anabaena sp. and contribute to the nuisance blooms on water.

The floating vascular plants are rather passive. They are drifted by wind and water current either in the water or on the surface. These include Pistia stratiotes (water lettuce), Lemna minor (duck weed), Ranunculus aquatilus (crowfoot), Nymphaea sp. (water lily) and Eichhornia spp. (water hyacinth) which float on the surface. Some others float below the surface i.e. submerged and these include Ceratophyllum spp. (horn wort), Vallisneria spp. (eel grass), Myriophyllum sp. (water milfoil) Elodea sp. and Potamogeton sp. (pond weeds).

The rooted and emergent plants are frequently confined to shallow lakes, rivers and streams and the shorelines of bodies of water. They are generally large and erect plants attached to the mud and most of the important ones have long narrow leaves like grass. This is an adaptive feature which reduces the evaporation surface and thereby lessens the rate of water loss from plant in dry conditions. Examples of these plants are the common reeds - Phragmites communis, the bur-reed Sparganium erectum and reed mace - Typha latifolia.

Beneficial Effects: Aquatic plants offer good spawning sites and substrates for the cyprinids, cichlids and nest making fish that prefer sheltered environment and plants to deposit their eggs on.

The salmonids on the other hand deposit their eggs among gravels and rubble on the river-bed of streams. A river with gravelly bottom in the temperate is a better bet as a salmonid spawning ground than a river with mud bottom and infested with weeds.

Plants offer to fish, escape covers from enemies and predators (Jackson, 1960). Anglers and fishermen take advantage of the attraction fish have for sheltered areas for they tend to concentrate under water plants and so fishing is enhanced. Because of good fishing achieved near sunken ships, artificial reefs have been used to improve sport fisheries in coastal marine waters in U.S.A. For example in Florida, commercial quantities of fish (about 25 tons) were attracted to underwater structure made of wood and covered with vinyl cloth which gave the structure a tent-like appearance (Everhart et al, 1975). This behaviour study showed the degree of attraction fish have for shelter in water.

Aquatic plants serve for food too. Some soft water vegetation are consumed by grass carp and herbivorous fishes while at the same time using them for weed control. The algae and phytoplankton are fed on by plankton feeders. In general, water plants help to maintain the natural cycles - food chain, chemical, oxygen and carbon dioxide cycles and nitrogen fixation by blue-green algae (Hickling, 1974). Some water plants e.g. Nymphaea sp. (water lily) which is widely distributed in still waters in the tropics, harbour an abundance of molluscs, insect larvae and other organisms on which fishes feed.

The environment is as well affected. Plants help in the consolidation of the bed and banks of streams, prevent the banks from slipping and protect them against erosion. Rooted plants anchor gravel and stones making the bed more habitable for invertebrates.

By interception of silt and plant detritus in running waters, the river bed fertility could be increased to the benefit of the organisms in the water.

Non-beneficial Effects: The physical presence of water plants can contribute negatively to fisheries, public health and welfare and nations economy.

In fisheries, the need to keep the waters free from excessive weed may demand the use of chemical herbicides. When these are not applied in correct concentrations, or because of other unforseen conditions, they could have direct toxic effects on fish. This situation would not have occurred but for the presence of and the desire to eradicate the weeds.

Dense growth of water weeds such as Eichhornia sp. and alga bloom sometimes disrupt fishing activities especially the operation of nets. Angling is also made very uninteresting and unpleasant by the unsightly massive alga bloom on water surface.

The wild growth of submerged and emergent plants encourages and leads to over-population with stunted fish and the eventual reduction of fish crop (Mahal, 1966).

There is always a chance of fish being killed by a sudden serious drop in the amount of dissolved oxygen in the water. Presence of excessive water plants can cause oxygen depletion at night in densely stocked body of water. Submerged green plants release oxygen into the water during the day as a by-product of photosynthesis. This oxygen is used by animals including fish in the water. At night when photosynthesis stops, the amount of oxygen drops (helped more by plants' respiration) to reach its lowest level at dawn. Excessive production of organic matter which eventually decays sometimes results in the fouling of the water. In both instances, oxygen depletion takes place due to respiration and decomposition respectively and in conditions of very low oxygen concentration, fish death may occur though oxygen concentrations as low as $\frac{1}{2}$ cc/l (0.7 mg/l) can be withstood by some coarse fish such as carp, tench and bream, Wunder (Varley, 1967).

Drawdown through evapotranspiration constitute a threat to fisheries. With decrease in water volume, fish spawns on the shorelines are exposed to dry weather. Water temperature may increase thus affecting fish stock and fish food. Evapotranspiration due to dense water hyacinth in India accounted for a loss of more than 6-acre feet of water in a 6-month period (Dasmann et al 1973). In fact the loss of water through evapotranspiration from the leaves has been measured as 3.2-3.7 times greater than free water loss from the water surface.

Plants cause recreation losses through interference with fishing, boating, swimming, sailing and other water sports. Lake and river navigation could also be disrupted by blockage of water courses by plants.

Public health and welfare are affected by aquatic plants. Water lettuce and lily provide good habitat for the larvae of several mosquito species that carry filariasis and malaria in the tropics (Welman, 1948). They also provide favourable habitat for snails, <u>Limnae</u> spp. which are intermediate hosts of both fish and human parasites - <u>Diplostomum</u> <u>spathaceum</u> and <u>Schistosoma</u> sp. respectively.

Water plants of same family do occur even in different climatic zones. Welman (1948) found some plants of the same family both in Nigeria and the United Kingdom despite the climatic differences. Ceratophyllum demersum - a free floating and submerged aquatic plant which is in the United Kingdom (Robson 1968), has been found to be one of the troublesome aquatic plants in the Volta Basin in Ghana (Hall et al, 1966). The growth and spread of aquatic weeds in the tropics seems more because of the characteristic (heavy and intermittent) rainfall and the active erosion caused by heavy floods which scour and sweep the river beds. Consequently the surrounding land is inundated. Swamps are created and waterplants that develop are mainly lacustrine in habit, though some aquatic plants take advantage of drought periods and develop in rivers.

Apart from the vascular plants which are common in tropical waters, the algae are usually the most troublesome in ponds and semi-stagnant waters. They form scum on water surfaces, slime on rocks or stones and grow in characteristic entangled mats known as 'blanket weeds'. Alga bloom occurs when conditions are suitable for their rapid growth and multiplication. Their presence not only makes the water to lose its aesthetic quality but causes physical interference of water flow.

In irrigation channels, sometimes the flow of water is obstructed by the presence of these plants, resulting in silt deposition and consequently in an increase in the expenditure on clearing and maintenance of canals. Silting and choking may cause overflowing of water which in turn goes waste and damages neighbouring farms or fishery projects. The cumulative process of silt and organic matter deposition could bring about changes in the plant and animal communities - generally increasing the density of weeds and tending towards the development of marshes and eventually dry land.

Although some of the algae do serve for food for man and domestic animals and even fish, it is known that some of the blue-green algae in the bloom produce substances toxic to fish and other organisms (Robson, 1968).

Water plant invasion of tropical and subtropical waters e.g. Kariba reservoir (Jackson 1966) Jebel Auliya Dam in Sudan (Little 1966) and Volta Basin in Ghana (Hall et al, 1966) seems a common feature. The cause of this could be climatic. Alternatively the effects of pollution and improper planning can contribute to it.

Weed Control: Fishery and water management policy requires adequate control of aquatic plants. It is often better not to effect a complete elimination because of the plant's beneficial functions in the aquatic ecosystem.

The control measures are varied i.e. mechanical, biological or chemical herbicides. All the methods except biological are deployed by the Water Authorities and Inland Drainage Boards of the U.K. which are responsible for the waters and rivers - their management and upkeep. The biological measure if applied must be on a very insignificant scale.

Mechanical: The mechanical method involves the use of scythe and other sharp instruments in cutting the weeds. The dislodged plants are removed to avoid their decay in water which might cause pollution by a build up of Biochemical Oxygen Demand (B.O.D.). Failure to remove the cut weeds from the water is an offence against the Rivers (Prevention of Pollution) (Scotland) Act 1951. (See Chapter 4.3.2). It is also an offence against the Rivers

(Prevention of Pollution) Act 1951 and Salmon and Freshwater Fisheries Act 1923 for England and Wales for leaving in water something injurious to fish, spawn or food of fish. (Chapter 4.3 (1 and 2)).

Other physical methods involve:

(i) Dredging - which may solve two problems - removal of weeds and removal of silts and debris.

(ii) Burning - may be more useful on river banks and in ditches for weed control.

(iii) Hand cleaning - effective on new infestation of emergent weeds though it is time consuming and limiting because of water depth.

(iv) Drying - where the possibility exists, the water could be run off to keep the water bed dry for some time. Through this method, the submergent plants will die off after several days of exposure to sun and air. In the temperate zone if the water is drawn down in winter and the lake not allowed to refill until spring, many aquatic weeds will die (Klingman and Ashton, 1975).

Biological Control: Fish are often used for biological control of aquatic plants. Pruginin and Lipschitz (Hickling, 1971) utilised 4000 carp to clear one hectare of *Myriophyllum* spp. which is a submergent weed. He did not state how long this took. The chinese grass carp, *Ctenopharyngodon idellus* is presently reared for sport and weed control in a pond infested with weeds (Ranunculus cicinatus and Myriophyllum spicatum) in North of England by Salmon and Freshwater Fisheries Laboratory, M.A.F.F. London. The pond holds a good stock of coarse fish but angling is almost impossible because the water is solid with weeds. Weed control by grass carp has not yet been achieved but experiment is still continuing (Buckley and Stott, 1977). The Chinese grass carp, C. idellus, has the reputation for consuming large quantities of water plant. Sills (1970) observed that 2,000 grass carp weighing between 0.25 to 0.5 lb. in a 20-acre pond with a 5-year history of excessive growths of Najas sp. and Potamogeton sp. could cause the disappearance of all the rooted aquatic vegetation within six weeks.

Tilapia species although primarily plankton feeders, some of them like Tilapia melanopleura, T. zilli and T. mossambica have been found to consume a variety of rooted aquatic plants and soft water vegetation, Lahser (Sills, 1970).

The possibility of using manatee, a harmless large mammal, is being explored. It is known that this mammal eats large quantities of most water weeds; Allsopp (Little, 1966). Manatee idea may seem impracticable because almost nothing is known of its physiology except that its breeding is slow. This animal can attain a weight up to a ton, so a method of handling it must be evolved. For its attraction, its safety from destruction by man, for meat should be ensured if it is to serve some useful purpose in weed control.

Chemical: Not all herbicides are approved by Pesticide Safety Precaution Scheme (P.S.P.S.) for use. Paraquat, Diquat, Dalapon, 2-4-D amine, Terbutryne, Chlorthiamid and Dichlobenil are among the approved herbicides. 2-4-D (amine salt) and dalapon are good for bank-side vegetation while diquat, paraquat, dichlobenil, terbutryne and chlorthiamid are used for aquatic vegetation (Newbold, 1975).

The use of chemical herbicide is relevant to legislation concerning fisheries and river pollution in the United Kingdom. Under the Rivers (Prevention of Pollution) (Scotland) Act 1951 and 1965 and Rivers (Prevention of Pollution) Act 1951 (for England and Wales) it is an offence to allow any poisonous, noxious or polluting matter to enter a stream. Also under the Salmon and Freshwater fisheries Act 1923, it is an offence to put any liquid or solid matter into waters containing fish to an extent that will make the waters poisonous or injurious to fish, fish food or spawn.

Where a herbicide introduced into a stream causes damage, it may be considered to be 'poisonous, noxious or polluting matter' under the above Acts. It is therefore essential to consult the Department of Agriculture and Fisheries for Scotland and the appropriate Water Authority in England and Wales before using any herbicide in a stream or any water draining into a river system.

Where chemical herbicides are used, they could show short term effects, Fig. 7. These effects which depend on the type of chemical herbicide, concentration and frequency of application are due to habitat destruction which brings about temporary changes in the environment (Newbold, 1975).

Chemicals for underwater weeds are limited. The risk of fish destruction is a matter which limits the range of chemicals and their concentration where it does no harm to fish. Newbold (1975) recorded no adverse effect on fish stock of diquat and

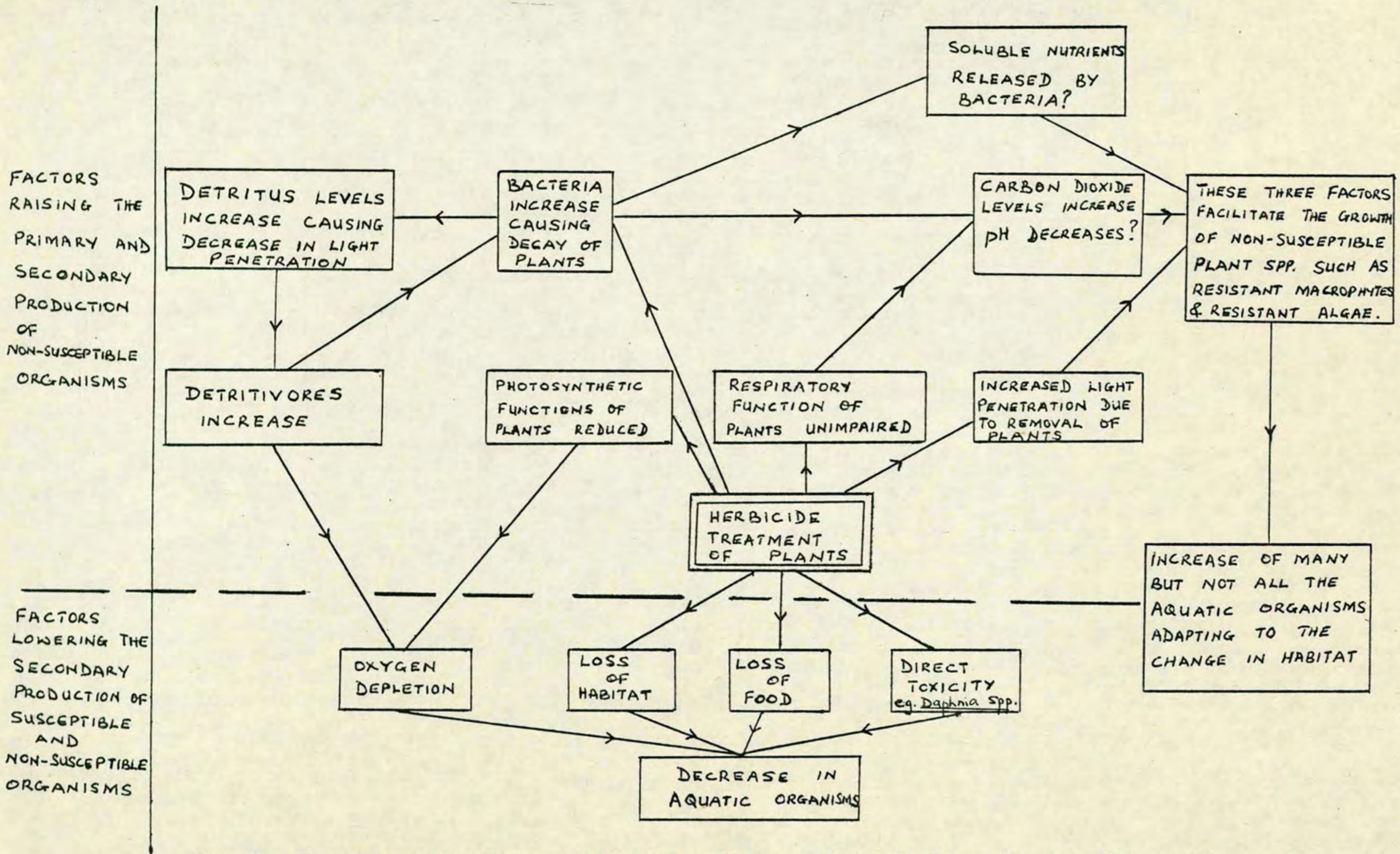


Fig. 7. Possible short-term ecological effects of herbicides in aquatic systems. (Newbold,1975).

paraquat applied at a concentration of 1.0 mg/l each in the control of some floating and submerged weeds e.g. Nymphaea sp, Ceratophyllum sp. and Potamogeton sp.

Terbutryne, a total algicide, is used for the control of submergent and floating macrophytes. It has a peculiar way of disrupting the photosynthetic function of plants. It is persistent in water and without significant effect on most invertebrate groups.

Copper sulphate, which is an algicide, has been contended to be toxic to zooplanktons and insect larvae (Shiff & Garnet, 1961), molluscs and fish (Shaw & Brown, 1974) and fish, Hasler (Mills, 1971). However Kessler (1960) controlled the growth of blue-green algae with copper sulphate at the rate of 1.5 kg/1000 m^2 of water in early spring and noted no harm to fish.

The solubility of herbicides in water depend on their formulation. Liquid compounds like diquat (Reglone) and paraquat (Gramoxone) give better miscibility with water. Herbicides are either contact or translocatory killers. They can be total or selective for spot treatment only where amenity value and conservation are important. Total herbicides are more drastic than the selective herbicides. The latter allows non-susceptible plants to flourish and colonise thus providing a new habitat for vertebrate and invertebrate fauna. Total herbicide on the other hand, by removing all dominant plant species can cause an ecological damage.

At times the effects of some herbicides are slow to come up. These are attributed to volatilisation, rate of breakdown by light intensity and bacteria which are governed by oxygen, temperature and pH factors (Newbold, 1975). Certain herbicides are cationic e.g. paraquat and diquat. These easily chelate to suspended solids and mud particles, which are normally negatively charged, on contact to become ionically bound. This might explain why herbicides like diquat, paraquat and other cationic ones often lose their potency when applied in turbid waters.

Cost: The need to keep waterways free from excessive weeds has called for national spending. In countries where many waterways which serve some national economic and other useful functions are infested with aquatic plants, their control often involves some financial loss.

In the United Kingdom there are about 162,509 km of waterways (canals, main rivers, dykes, private ditches and intermediate water courses). The regional water authorities of England and Wales and the local river purification boards of Scotland manage 9,654 km of the 30,571 km of rivers (Newbold, 1975). These bodies together with the farmers spent about £6 million on weed cutting and some £2.6 million on herbicides to control bankside vegetation and aquatic weeds in 1972.

On the average, aquatic weed control through mechanical methods is estimated to cost £10/km, cutting bucket £15/km, hand labour costs £33/km and recommended herbicide dose costs £25/km (Robinson, 1971).

Weed control with 2-4-D was initiated at an annual cost of $250,000 on Lake Brokopondo by Surinam Government. In Sudan the government spends about £500,000 each year in an effort to control the heavy infestation of E. crassipes on the White Nile and check the weed from spreading downstream past the Jebel Auliya Dam.

Chapter 4

4.1 METHODS OF CONSERVATION AND MANAGEMENT

4.1.1 HABITAT IMPROVEMENT

Many river systems with time accumulate obstructions of one sort or another. These obstructions may result from defforestation, lumbering processes and log jams or silt accumulation due to changes in land drainage. Obstructions constitute a barrier to migratory fish. Sand and gravel bar formations also block either the inlet or outlet streams of lakes which may be used as spawning and nursery areas by fish that naturally restock the lakes. In the circumstance, habitat improvement is necessary not only for the benefit of fish but also other organisms on which fish live.

Improvement practices involve removal of obstructions or creating facilities for passage through obstructions. It also involves river bed and water quality care and general improvement that will favour fish spawning, growth and production.

Where dams or weirs occur, fish passes should be established (Chapter 3.3). Fishways are channels, water filled locks or series of connected pools (Fig.8) by which fish may swim or be carried over or negotiate around an obstruction (Everhant et al, 1975). The common and simple type of fishpass is the pool type i.e. fish ladder shown on Plate 2. The pool type is a succession of pools connected by short rapids. They have submerged openings. The pools are usually deep and wide enough to prevent strong currents of carrying over of energy from pool to pool. The depth of each pool is about 3'6", length about 8'0" and width about 6'0", Fig. 8 (A, B, & C).

Other types of fishpass include Borland fish lift, denil with channels of closely spaced baffles, inclined chutes and simple sluices. The basic principle of these fishpasses are such that they can operate at all reservoir water levels and volume of stream flow. The entrance to fishpasses will be so made to be easily found and passage achieved without delay. The fish must have the ability to ascend or descend the pass without injury or excess energy exertion. Because of the leaping behaviour of some fish like salmon and trout at falls and obstructions, provision of inclined ramps leading to a fishpass might facilitate the downstream movement of migrants (Stuart, 1962).

Borland fish locks (Fig.9) like the fish ladder provide passage across hydrodams (Chapter 3.3) for migratory fish in Scotland. On the down-stream side of the dam, fish are attracted by a flow of water into a chamber at tail race level. Fish having entered this chamber a sluice is short behind it and the water which has been flowing gradually rises the water level in the chamber to that in the headpond or reservoir. Fish then proceed to the reservoir. For dams up to 20 ft. high, the chamber is an open one. For higher dams there is a top as well as a bottom chamber and they are joined by a sloping shaft which gradually fills as water level rises after the downstream sluice has been closed. The Borland fishpass has many advantages, for example, fish overcome obstacles without effort, the design fits into general design of dam and it is cheaper and more economical in use of water (North of Scotland Hydroelectricity Board Report, 1963).

The success of a fishpass depends on its siting, design and the technological expertise incorporated for easy passage of fish. Fish guiding devices are also necessary to direct the fish to the

Fig. 8. Diagrams A, B, & C showing different views of pool type fish-pass i.e. Fishladder. (Everhart et al,1975).

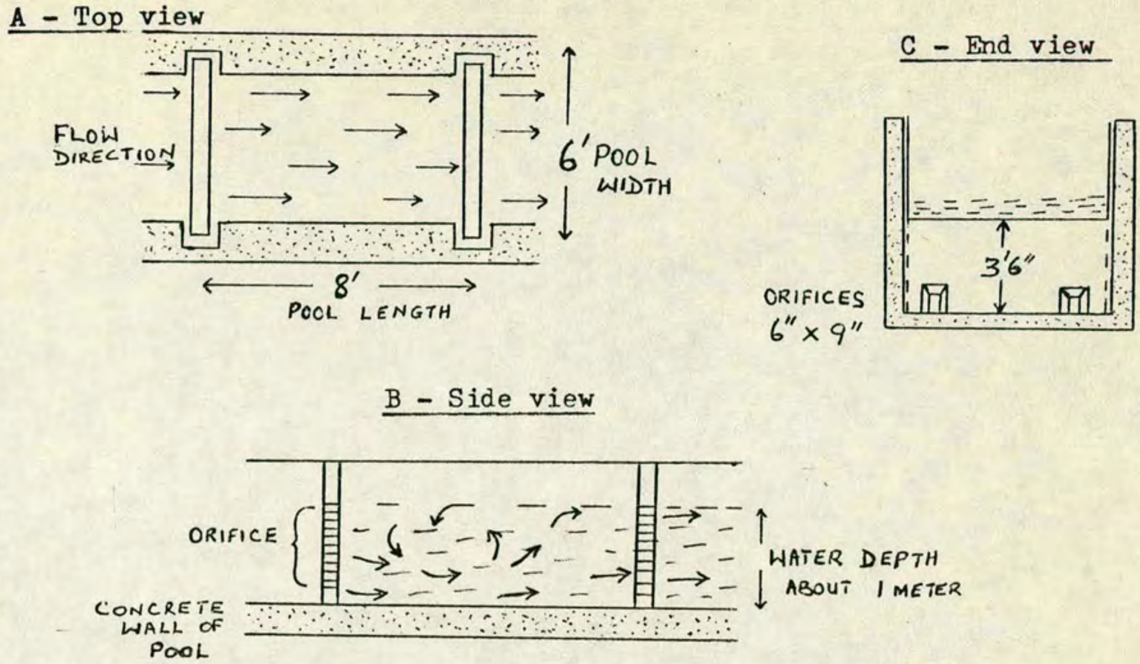
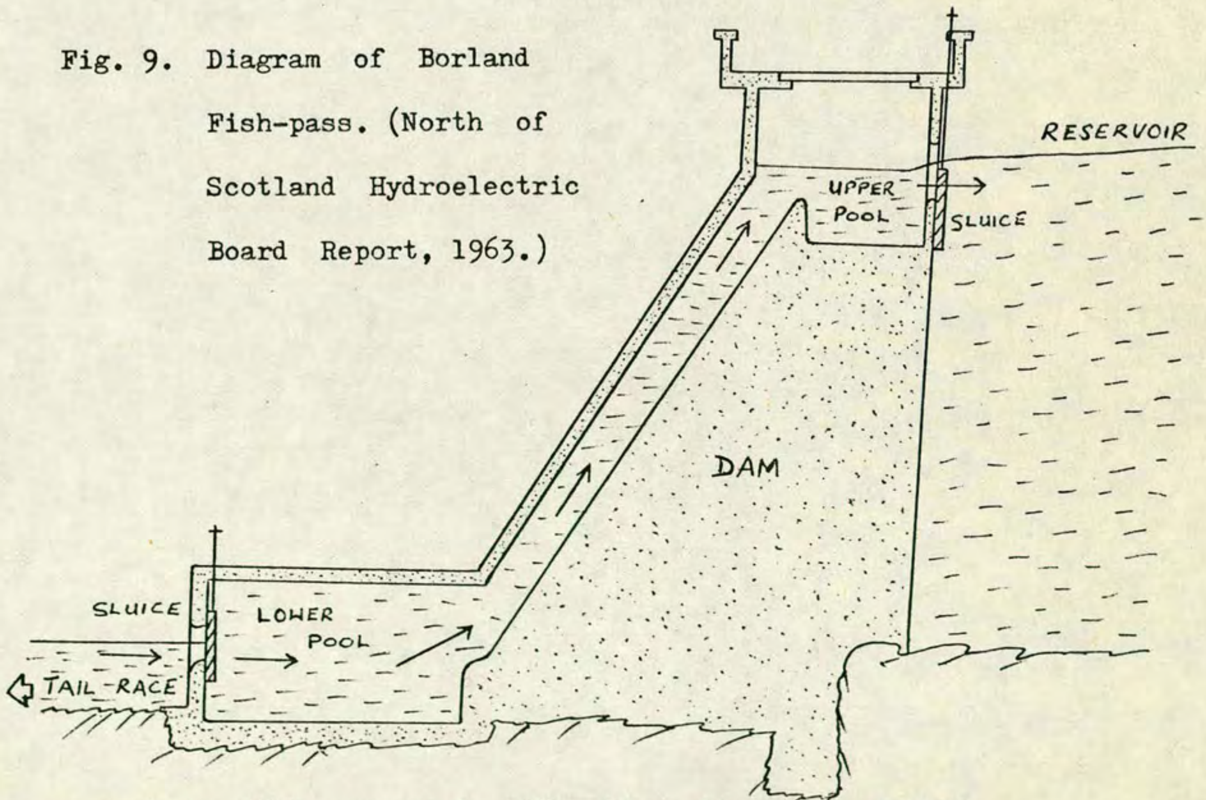


Fig. 9. Diagram of Borland Fish-pass. (North of Scotland Hydroelectric Board Report, 1963.)



→ shows fish movement with flow direction across the sluices to the reservoir.

fishpass and protect them from getting into the hydroelectric turbines as discussed earlier.

Where the water current of a stream is not satisfactory, increasing or decreasing it can be achieved by use of deflectors, weirs and groynes. The deflectors consist of a single boulder or large boulders. They can also be made of log and cement blocks. By laying these deflectors at an angle on the stream bed from the bank, they help to speed up the water current, washing out silt and providing gravelled riffle areas for spawning of salmon and trout. The deflectors scour the stream bottom and provide more movement in the pools. With the increased current the water will have less chance of exposure to the sun thus maintaining the low temperature required by the salmonids.

Weirs serve useful functions in helping in pool formation upstream of the structure. In many Scottish rivers like the Fyne, where improvement of the river flow is needed, weirs have been established. The River Fyne in Argyll is affected by the Sloy-Shira Scheme of the North of Scotland Hydroelectric Board. This scheme, since its establishment and incorporation of Rivers Fyne and Kinglas, has changed the flow regime of River Fyne. It has caused a reduced average daily flow (adf) in the Fyne. Weirs were then established to provide holding pools and shelter for returning salmon and sea trout.

Erosion prevention and stream bank protection are important too. The Maccaferi gabions serve a useful purpose in protecting and reinforcing the area of bank scoured by stream. These Maccaferi gabions are large, steel wire-mesh baskets filled while in tension with clean boulders and stones. They are usually rectangular in shape, variable in size and galvanised to ensure long life when in use either around or under water. They are either prepared and transported or prepared at the site where they are needed. These eventually form a natural substrate for some aquatic organisms. The easily and commonly adopted methods of bank protection against erosion are the reinforcement of scoured bank with stones, brushwood staked in with trees, terracing, formation of concrete tree trunks and growing of undercovers like grass on the banks.

Current diversion with groynes or boards secured to stakes helps to prevent erosion. Where river flow runs in multiple channels, gabion groynes are used to control the watercourse in straight channel and concave bands particularly.

Aquatic plants though not in excess could be allowed on the littoral zones of lakes, stream banks and pond edges. The role of aquatic plants in fisheries in the tropics and in stabilising stream and river banks is discussed in Chapter 3.6.

Artificial destratification by recirculation and aeration can help to improve fish habitat. Recirculation by use of outboard motors to churn the water or arrangements made to pump the hypolimnion water of the lake to the surface can clear the problems caused by thermal gradient, stagnation and ice-cover. Such problems are likely to be plankton blooms and oxygen supply shut-off because of ice-cover. Thermal stratification can influence the distribution of fish-stock, micro and invertebrate organisms. Plankton bloom on the other hand, while increasing chances of food supply to man, fish and other organisms, will create recreational and industrial problems.

Hunt (1969) showed the benefit of fish habitat improvement. He reduced the amount of sand bottom and silt bottom by 40% and

70% respectively. The stream gravel bottom was increased from 4% to 11% (10% mostly gravel). The number of pools was increased by 52% while the area of stream bottom in pools was also increased by 170%. Following these alterations, an average biomass of 68 lbs. of Brook trout, Salvelinus fontinalis, was recorded between 1965-1967 as against the average biomass of 23 lbs. recorded in 1961-63, i.e. pre-alteration period, on one mile long section of Lawrence Creek in Wisconsin.

Water Quality and Improvement: Swingle (Hickling 1971) considers water with a pH ranging from 6.5 - 9.0 before day break as the most suitable for pond culture. In more acid waters, important fish food organisms fail to grow normally, pH levels below 5 and above 9 are detrimental to fish (Mills, 1971). Acid waters diminish fish appetite and thereby reduce their growth rate. Fish food organisms are also diminished. Generally acid waters have a poor biogenic capacity (i.e. ability to support life).

Biogenic capacity is designated B in the formula used in estimating annual production, Huet (Mills, 1972).

$$K = B \times k \times 10$$

where K = annual production Kg/ha

B = Biogenic capacity

k = Coefficient of productivity which can be k_1, k_2, k_3

where coefficient k_1 is given a value to average water temperature

k_2 relates to acidity or alkalinity of the water

k_3 indicates type of fish (salmonid or coarse)

Biogenic capacity is evaluated on a scale from 1-10

1, 2, 3 correspond to poor waters

4, 5, 6 " " average waters

7, 8, 9, & 10 correspond to rich waters

Southern (Mills, 1971) noted that brown trout grew more rapidly in alkaline than acid waters. But Pentelow (1944) believed that growth rate depended more on the relation between the trout population and the food supply than on chemical composition of water. He said that trout can grow into a large size in acid and alkaline waters and pointed out that the survival rate of trout in acid water is much higher in the early stages due to physical suitability of the spawning grounds.

On the other hand, Horton et al (1968) observed that high survival rates and consequent high population density leads to a slower growth rate in acid water. They found that faster growth rate of trout in one stream, out of the three streams investigated in Devonshire is correlated with low fish densities due to unfavourable spawning and high bottom fauna production while in the other two streams poor growth rate is correlated with poor bottom fauna and favourable spawning grounds.

Campbell (1960) showed that the growth of brown trout in some Scottish lochs with little or no spawning facilities was much better regardless of the pH and alkalinity than in lochs where spawning facilities existed. In other words, growth rate is more dependent on population density.

The condition achieved by fish apparently is not as a result of one factor. Dahl (Mills, 1971) believes that growth is a product of exterior influences. Mills (1967) observed that growth rate of trout is not entirely dependent on population density but is influenced by other external physical factors like nature of vegetation and water temperature of the stream.

Addition of limestone as an improvement measure is necessary to buffer the acid effect and build up the calcium carbonate content of the water. Many of the dystrophic lochs which are found mainly in moorland, boggy and mountainous areas in Scotland, though may be rich in organic matter, consist of undecomposed peat and other humic materials. There is little decomposition in these waters because of a deficiency of calcium. Limestone makes these peat coloured acid lakes and ponds clear. As they become neutralised, the water turbidity is reduced thus allowing light penetration into the water. The limestone counteracts the possible harmful effects of excess magnesium, sodium or potassium ions, speeds up the decomposition of organic matter, weakens phosphorus ion-bond and thereby facilitates the passage of ions e.g. calcium into the water. It helps to accelerate nitrification, ammonification and fixation of free nitrogen. It also assists in the release of nutrients from the soil and promotes the bacterial breakdown of waste material. By raising the pH of water, it stimulates the growth of algae and development of microflora, Wolney (Hickling, 1971).

More often, fertilization (with nitrogen N, phosphorus P, and potassium K (N.P.K.) of lochs and ponds follows lime application. In ponds, conditions of productivity differ widely from lakes. Dead organisms in ponds readily decompose and enter the food chain immediately while in a lake they deposit under the thermocline and are kept from entering the plant nutrition cycle for long periods or become permanently sedimented. However the littoral zone of a lake, where there is no thermocline, resembles pond conditions. The principal gains in pond productivity result from the addition of phosphorus. Lakes with extensive littoral zone therefore will respond favourably to fertilization with phosphate.

Fertilization of trout waters when done at random can be disastrous. It could result in algal scum which covers the lake and causes oxygen depletion. The amount of fertilizer to be applied depends on the water/soil requirement. The quantity of phosphate (as superphosphate in the fertilizer) to apply also depends upon the extent of growth of large aquatic weeds such as Nymphaea sp. and other submerged floating weeds. Where these are not abundant and the water is fairly hard, a fertilization rate of about 12 kg/hectare (10.7 lbs./acre) in one dose is sufficient in spring (Mills, 1971). If aquatic plants are abundant, the benefit of fertilization to fish may be masked since these plants will take up large quantities of the phosphate and grow extensively.

Fertilization can give improved growth rates and benefits to fish. In four Scottish lochs where fertilizer was applied, though there was a 2-year delay in an increased production of bottom fauna, the trout showed immediate response to fertilization with a much improved growth rate (Munro, 1961). Mills (1969) noted a substantial increase in the standing crop of young salmon (2.8 g/m^2 - 4.2 g/m^2) in one of the three moorland streams in Scotland he worked on. He attributed this increase to the addition of mineral fertilizer to the loch at headstream and an increased discharge from a septic tank which flows into the stream. In the other two streams not affected by fertilizer, the standing crop remained similar each year (1.0 g/m^2 - 2.0 g/m^2). Bags of fertilizer placed on the shores of a barren stream in Nova Scotia had beneficial effects with a resulting growth of algae, rooted plants in the mud and increased survival of planted salmon fry when previously few had survived (Huntsman, 1948).

Pond depths: Where fish are reared under controlled conditions, the depth of the ponds and fish farms should be considered. Ponds that are too deep could run a risk of having a thermal stratification like in deep lakes. The bottom layer of the water i.e. the hypolimnion may become deoxygenated particularly in the presence of mass decomposing organic matters and where free circulation is hindered by dense bank vegetation. An average depth of 7 ft. for trout ponds with continuous inflow and outflow of water is considered sufficient (Mills, 1971). But where intermittent flows of water occur, some parts of the trout pond could be at least 12 ft. A pond depth of about 6 ft. for trout rearing to ensure good oxygen condition and a good habitat for the cold period characteristic of the temperate zones is also suggested (Hickling, 1971).

Very shallow ponds for rearing and production, in the tropics are likely to suffer from an overgrowth of coarse vegetation. Pruginin and Ben Ari (1959) suggested a minimum depth of 2 ft. 6 ins for ponds in the tropics to avoid the problems associated with very shallow ponds. Hickling (1971) in advocating 3 ft. as a working depth for fish rearing ponds in the tropics maintained that it would be too deep for most hard water plants, water won't easily be overheated and that the water would be deep enough to absorb all sunlight for primary production.

Although certain average working depths are expected in fish ponds, the determination of the pond depth really depends on the altitude of the site, water supply conditions, the fish being cultured and the climatic zone (temperate or tropical). Ponds for the trout in the temperate zone have their peculiarities so that favourable environment would still be maintained as much as possible irrespective of the weather conditions.

4.1.2 ARTIFICIAL PROPAGATION

In fisheries management, artificial propagation involves planting out of fertilized fish ova or hatchery reared fish into streams, lochs, rivers and ponds. As a part of management programmes, it is done to increase the fish stocks in areas which are either underpopulated or inaccessible due to obstruction to spawning adults. Where obstructions exist and prevent fish from getting to their spawning sites, traps can be erected below the obstruction to catch adult fish for stripping and artificial fertilization.

The stripping of ripe hen fish and cock fish for their eggs and milt respectively is done by holding them vertically in a relaxed position with the tail pointing downwards. Usually a noose which is placed around the 'neck' to hold it up, helps to keep it relaxed. Slight rubbing down with gentle pressure is applied with the fingers on the ventral side of the body. The eggs are collected in a dry basin. The milt from the cock fish is used to fertilize the eggs. The milt is mixed well with the eggs gently by use of a feather or with the hand. They are covered with water which is decanted two or three times to remove the cloudiness caused by the milt. This could be repeated until the water is clear. The eggs are allowed to swell up and harden for about two hours before being moved. Any jolting at this critical period (i.e. period before hardening) can result in a high mortality of the eggs. Apart from mechanical shock, thermal shock can cause a high mortality. When the eggs are hardened they are known as 'green' ova. Where a hatchery is available the 'green' ova are held until they have become 'eyed' and hatch into alevins. 'Eyed' ova are more resistant to rough handling than 'green' ova and can travel safely for about 24 hrs. if kept moistened. The hatching period for the salmon ranges between 70-160 days depending on water temperature. The lower the water temperature the longer it takes for the eggs to hatch.

Artificial propagation is worldwide though it might be on a different scale depending on needs and objectives. It is probably more in countries where angling is based mostly on put and take fisheries and where sport fishing provides much of the recreation needed by the public.

A survey of the organisations and bodies connected with fisheries development in England, Wales, Scotland and Ireland revealed that about 87% of them carry out artificial propagation under the policy improvement scheme. Despite this high rate, artificial production of salmon in the British Isles and Eire is low and insignificant, (Davis, 1970).

In Scotland most of the salmon District Fishery Boards are engaged in artificial propagation. They trap salmon, strip them, hatch their eggs in hatcheries and plant out either the unfed fry or the underyearlings. In May 1965, approximately 1.3 million fry were planted out in the tributaries which enter Loch Shin and Loch Merkland by the Shin District Fishery Board. The Awe District Fishery Board planted out 650,000 fry in 1964 and incubated 1.02 million eggs in their hatchery at Inverawe in 1965. The Tay District Fishery Board planted in her waters more than 300,000 fry produced from the Board's hatchery at Pitlochry in 1965. The Conon District Fishery Board planted 6.5 million fry in 1965 in the Blackwater, Bran, Meig and even in the inaccessible headwaters of the Orrin by use of helicopter. About 7.5 million eggs taken from 4,251 salmon and grilse at Loch na Croic trap were incubated at Contin and Invergarry hatcheries (Ann. Report 1965-1966, North of Scotland Hydro. Bd.). The North Esk Fishery Board in 1976 distributed 175,000 unfed fry and 108,000 'eyed' ova for planting in her area.

It is not always that artificial propagation proves useful. Where possible, attempts should be made to restore the river's own production capacity either by stream improvement or opening up of new grounds to the fish. For example Rivers Fyne and Kinglas gave a poor production of salmon and sea trout in recent years and this was reflected in the angling catches. On investigation into the causes, Mills (unpublished) suggested river improvements to be carried out so as to raise the production capacity of the rivers (River improvement already treated in Chapter 4.1.1). He suggested, also, that artificial propagation as a final step should be adopted to improve production. In April 1975, 100,000 unfed sea trout fry were introduced into the River Kinglas and in May 1975, approximately 50,000 unfed salmon fry were released in the upper reaches of the River Fyne. Hunt (1969) has also shown that by improvement of the habitat, production capacity of rivers can improve.

There is little benefit derived from planting of fish eggs or fish (fry or parr) in waters where natural spawning occurs successfully. Fish introduction is only necessary when the number of spawners is too low for an adequate occupation of the area and the number of fry produced are inadequate to utilise fully the resources (space and food) available in the environment. Where sufficient fry are produced and more are introduced, competition for survival will increase and many of either the introduced or naturally spawned fry will die. By the thinning out of the population, an equilibrium is maintained between the fry and the environment. The survivor form the carrying capacity of the environment i.e. the population the environment is capable of supporting indefinitely in good condition.

Propagation Stages: Artificial propagation is often carried out at various stages from 'green' ova stage to adult stage. What really matters is the availability of facilities to rear the fish to a particular stage, the convenience of the time of planting and which stage of planting renders the best result.

Planting of eggs is done either at the 'green' or 'eyed' stage when they have hardened and become less susceptible to damage by rough handling. The percentage hatching of young salmon in streams stocked with 'green' ova for over three years was recorded as 90.9, 87.6 and 84.6 respectively by Shearer (Mills 1971). The number of eggs to be planted out depends on the stream's characteristics - physical and chemical, predator population and strength of existing stock. For Pollet River whose characteristics are known, Elson (Mills 1971) estimated 200 eggs/100 sq. yds in order to get the maximum smolt production.

Most introductions are made at the unfed fry stage that is the immediate post alevin stage when yolk sac absorption is almost complete. Most of the plantings by District Fishery Boards in Scotland are done at this stage. This stage seems fraught with danger for where predators abound, heavy mortality would be recorded and where circumstances e.g. low water level or pollution do not permit the planting of unfed fry at the supposed time, the nutrients in the sac could be exhausted and high mortality would occur.

Where facilities exist, the fry are kept in the hatchery and fed until they become fingerlings or underyearlings before they are planted out. This stage has less chances of high mortality at planting than the unfed fry stage. It is not easy to determine how many smolts an area planted with salmon fingerlings can produce. This depends on external influences particularly the trophic relationship with other organisms. Knowledge of smolt production in an area will determine the number of fingerlings to be planted out after making an allowance for environmental stresses. Elson (Mills 1971) estimated that in order to produce about 1000 smolts per mile of stream of 10 yds. wide flowing through a fertile soil with bird predators (e.g. merganser) not exceeding 1/10 miles of stream of 10 yds. width, about 7000 underyearlings/mile of stream of 10 yds. width should be planted. In poor waters with no predator control about 2,500 - 3,500 underyearlings should be planted for a maximum expectancy of 400 smolts. The percentage survival of unfed fry to the smolt stage on the River Bran was about 3% which implies a smolt production of 3.5/100 sq. yds. (Mills, 1964).

Often a low or poor return of hatchery reared fish is recorded even where equal number of hatchery reared and wild fish are released in the same river. The cause could be attributed to environmental factors and stocking density. The rearing conditions result in the poor state of the fish in natural environment. The rearing condition also reduces their viability thus making them difficult to cope with daily activities e.g. swimming, searching for and using natural food and evasion of predators. The low recapture of hatchery reared fish when compared with the wild fish is often attributed to the poor state of the hatchery reared fish in a natural environment. Shearer (Mills 1971) noted in his two experiments that the proportion of wild smolts recaptured was much greater than the hatchery reared smolts recaptured (1.9% and 0.28%). The North Esk Fishery Board recorded a higher percentage recapture of wild smolts, of both the hatchery reared and wild smolts released in their area between 1961 and 1975 (North Esk Fishery Board, Ann. Report 1976). Webster (Everhart et al, 1975) not only observed that the low return of hatchery-reared fish is the result of chemical, physical and physiological change brought about by hatchery operations, noted also that wrong planting time and in an unsuitable place could be a contributory factor.

Overstocking is rarely successful. In an experiment to determine the survival of hatchery reared salmon fry in some Scottish streams, Mills (1969) noted that fry survival is affected by stocking density. Stocking rates 12.0 - 15.0 fry/m^2 in moorland (usually chemically poor) streams are wasteful and give a similar production of young fish as stocking rates of 2.0 - 5.0 fry/m^2. But in richer waters i.e. water running through agricultural land, a stocking rate of 10-15 fry/m^2 could be used. Stocking rates should not be so low as not to provide a reasonable insurance against natural accidents (Mills, 1969). Although high stocking density is undesirous in chemically poor waters, it is not primarily the cause of fry mortality. It is due to lack of correspondence between the stocking density and the streams capacity to provide the necessary requirements of territory, feeding stations, shelter and food for normal life (Egglishaw, 1967).

Hatchery-reared trout when compared with the wild ones has like salmon, yielded some low percentage recapture. Though Mills and Ryan (1972) observed a good recapture (of about 41.2%) result of hatchery-reared brown trout released into the River Tweed in the County of Peebles for the benefit of anglers. They attributed the insufficient recapture to mortality due to inability of the hatchery reared trout to compete for food and territory with the existing stock.

Despite the low returns and recapture recorded, improvement policy of artificial propagation is still concentrated on the salmonids (salmon and trout) in the U.K. because of their amenability to hatchery culture, importance to commence and recreation and the existing limiting factors to natural spawning.

The benefits of artificial propagation are not hard to realise. It satisfies both short and long term demands. Addition of new species of fish to existing stock is also achieved. Fish are provided for new bodies of water for restocking after chemical reclamation or natural catastrophy.

Where angling pressure is high, the waters are stocked with hatchery-reared takeable fish in order to meet the angling demand. In such put and take instances, not much attention is given to the carrying capacity of the water since all the stocked fish are of takeable size and are likely to be removed within short periods by ever-keen anglers.

<u>Alien species</u>: The proposed plan to introduce Coho salmon into the United Kingdom is receiving strong objections. The Pacific salmon which form one of the main commercial fisheries in the U.S.A., Canada and Newfoundland are known as well as the Atlantic salmon which are popular in the U.K. and some European countries, to be produced in hatcheries in almost unlimited numbers (Netboy, 1976).

The smolts produced are known to have considerable viability in the ocean and return to the streams where they were released thus adding to the runs available to sport and net fishermen.

The North Esk Fishery Board (N.E.F.Bd., Ann. Report 1976), Scottish Fish Farming Association, National Farmer's Union - Fish Farming Section, and individuals including anglers have called for an end to the plan to introduce Coho salmon into U.K. on the grounds that they are carriers of Infectious Pancreatic Necrosis (IPN) virus (even though they will be certified disease free before importation), their ecology is not fully known and finally there could be a possibility of their displacing the highly valued Atlantic salmon because of their prolific way of reproducing. Although some Canadian Coho salmon eggs were recently imported into Scotland, a threat of their destruction was issued by Minister of State for Scotland if the Government is not satisfied that they are free from disease. However, Marine Harvest Ltd., part of the giant Unilever Group, responsible for importing a small quantity of Coho eggs as part of their fish study programme have declared that the eggs are IPN free since they were got from British Columbia where there had never been any signs of IPN virus (Angler's Mail, 1977).

Similarly in U.S.A. when the Federal Government offered large grants to all the new England States to participate in the Coho scheme, an opposition was raised by conservation organisations (International Atlantic Salmon Foundation and Restoration of Atlantic Salmon in America) devoted to the restoration of Atlantic Salmon. They argued that the Coho programme will hurt efforts to bring back Atlantic salmon to New England and hence it should be delayed until a complete and accurate assessment of possible damage can be made. Nevertheless the scheme moved ahead in places like Massachusetts and

New Hampshire but the programme in New Hampshire has not been as successful as in Massachusetts (Netboy, 1976).

In the tropical environment, the commercial benefits achieved (Gee, 1969) in East Africa seems to have masked any problems in alien species introductions. Lates niloticus which are endemic in Lakes Albert and Rudolf were introduced into Lakes Kyoga and Victoria. The introduction of Lates sp. into Victoria was to feed on the more abundant 'trash fish' - Haplochromis sp. which are not of commercial importance. The pilot introduction of Lates niloticus into Lake Kyoga was to assess its effects on the cichlid dominated fauna. Much success was achieved in Lake Kyoga that Lates formed an increasingly important element of the commercial catches (Fig.10) by 1963. Although the introduced Lates niloticus increased in number and spatial distribution in Lake Victoria, it has not yet formed a significant percentage of commercial catches.

Gee (1969) established that the introduction had no adverse effects on Tilapia stock even though the cichlids form the most important elements in the diet of Lates niloticus. In Lake Kyoga from 1958-1965, there has been no consistent decrease in catches of Tilapia with catches of Lates, these having continued to increase considerably, Fig.10. Welcomme (Gee, 1969) also indicated that the trend in Tilapia catches on Lake Victoria were almost identical with those of Lake Kyoga and that fluctuations are closely correlated with rise and fall of lake level and availability of nursery grounds. Although there might be little effect of predation at present, Gee (1969) noted, the impact might increase in the future since Tilapia leave the nursery grounds at the most vulnerable size (about 3.0 - 17.5 cm.), liable to predation by Lates.

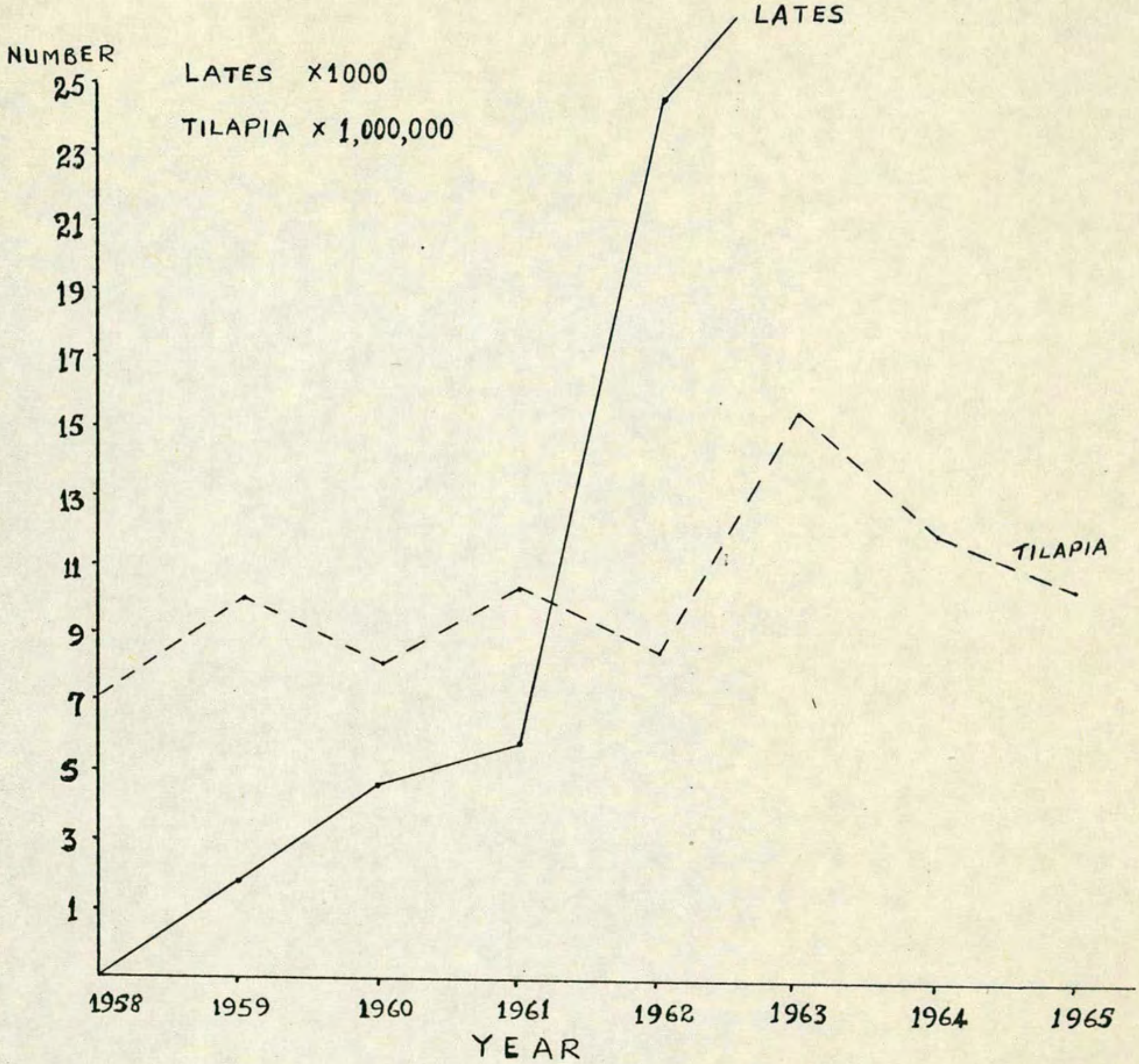


Fig. 10. The commercial catches of Tilapia and Lates from the nine most important areas of Lake Kyoga. By 1963, 1964 & 1965 Lates catches (number) rose to 188,547; 269,188; and 989,916 respectively.(Gee,1969).

Generally some thoughts are given to the influence of biotic and abiotic factors in the environment before alien species are introduced either for propagation or biological control purposes. The interaction between the new and the endemic stock can reduce or eliminate either through predation, hybridization and competition for food, living space and scarce resources as the Mississippi silver side - Menidia audens introduced into Clear Lake, Lake County (U.S.A.) for biological control of midges and blue-green algae multiplied profusely, reduced indigenous species and spread to other bodies of water, Cook and More (Moyle, 1976). Similarly competition from mosquito fish T. gambusia attributed to the decline of a number of pup fishes - Cyprinodon sp. of Southern California, Pister (Moyle , 1976).

The abiotic factors take into account the interacting influence of alien species, the climate and the physico-chemical properties of the new environment. The influence of the new environment may reduce the growth population of or completely eliminate the alien species. On the other hand the newly introduced may cause an alteration in the ecosystem. Such could occur in waters where herbivorous fish e.g. chinese grass carp, and some Tilapia sp. are introduced. In the same way, bottom, detritus and planktonic feeders could cause alterations in the aquatic ecosystem because of their feeding habit which tends to stir the water vigorously and make it turbid.

4.1.3 CONTROL OF PREDATORS AND UNWANTED SPECIES OF FISH

The control of predators and unwanted species of fish is often a regular practice in fisheries whether in the wild or reared environment. The extent of this practice depends very much on the degree of predator-prey relationship.

In the wild not all instances of predation may demand strict control as predators may not necessarily be injurious to fish of commercial importance. Ricker (Nikolskii, 1969) distinguished three possible types of predator to prey. The first relationship is when the predator takes a definite number of prey and the rest escaping e.g. breeding shoals of herring or migrating salmon smolts coming in contact with predators. This is a matter of chance and the number taken is governed by the time of contact with the predators, the number and activity of the predators as well.

In the second relationship, the predator takes a definite fraction of the prey population i.e. the number taken is governed by the numbers of predator and prey and is largely independent of time of contact. In this situation the predators depend on a particular prey population throughout the year.

The third relationship is such that the predator takes all available individuals of prey except those that escape by moving into inaccessible places. Here the number taken is governed by the availability of shelter and accessibility of prey to the predator. For example Elson (Nikolskii, 1969) showed that the number surviving out of the number of Atlantic salmon fry eaten by birds on the nursery areas is dependent solely on the availability of shelter from predators.

The third type seems most injurious to the prey and where this situation is established, strict predator control could help to reduce pressure on the prey. Often the pressure of a predator is dependent on the stage of development of the prey and the time (diurnal or nocturnal) of attack by the predator. But the knowledge of the time of attack alone is not sufficient for a proper control of predators. The knowledge of the food and feeding habits of the predator, the movement of the prey and their life cycle would be essential for tracking down predators that often trail their prey.

Fish predators are varied and many in Scotland. Fish of the salmonid family particularly Salmo salar and Salmo trutta predate on the smaller individuals of their own species and on other fish of less commercial importance. Pike which usually inhabit lochs and impoundments are known to be serious predators of salmon and trout as observed in the Conon River System (Mills, 1964) in Loch Choin (Munro 1957) and elsewhere.

Birds such as goosanders, red breasted mergansers (Mills, 1962), cormorants (Mills, 1965) and shags, (Rae, 1969) have been established as serious predators on fish in Scottish inland waters (tidal and non-tidal) and on the coasts. Other predatory birds are herons and gulls.

Predation by otters and mink are not as serious as that by grey seals. Rae (1968) was able to establish the food of seals in Scottish waters. Seal damage to Scottish Salmon Fisheries has also been established (Rae, 1960 and Rae and Shearer, 1965).

In the United Kingdom, predator control has been and is still practised both in the wild and reared conditions. However, control under reared conditions is much easier than in the wild. Some of the physical measures for the removal of predatory fish and unwanted species of fish include netting, electrofishing, traps, damage to spawns and water level control to affect spawns and spawning activities in reared conditions. For the terrestrial predators like birds, mink, otter and others, traps and use of firearm could be permitted.

Fish in reared condition are protected from terrestrial predators by use of wire fencing, traps, electrical barriers and gauze settings installed around important fish waters or farms. Overhead cables which are horizontally installed over fish farms as in Kenmure trout farm, Galloway and the Yorkshire Water Authority trout farm at Pickering, prevent fish-eating birds from diving to take their prey.

Gill nets have been set to remove pike from waters where their presence is undesirable. Seine nets have also been used to clear some bodies of water of unwanted species of fish before new introduction or transplantation of fish is made. Gill netting for pike is a slow process and no assurance can be given that only pike will be caught.

In the alternative, a faster method by use of chemical (rotenone) to clear or reduce pike population from lochs, is deployed, if the lochs are wanted for a trout fishery only. In Dunfermline, Scotland, rotenone application was made on Loch Fitty - a lowland loch in order to clear it of predatory fish like pike before it was stocked with trout by Games Fisheries Ltd. From this loch vast quantities of fish were removed and amongst them were pike - 0.75 tons; perch - 1.84 tons; and eels - 0.7 tons (Mackenzie, 1975). Some quantities of trout were also affected by the piscicide.

Loch Choin in Scotland, was formerly a good trout loch but later became infested with pike due to changes in the ecosystem of the loch. In the recent years there had been no record of trout caught in the loch but the outflowing stream Allt Choin still contained trout. In 1955 the pike population in the loch was eliminated by use of rotenone with a view to restoring the loch to its former fishery. 160 gallons of derris extract (2½% rotenone) were distributed over the loch to produce a concentration of 0.06 p.p.m. rotenone (2.5 p.p.m. derris extract). About 2,078 pike were recovered from the loch and of this quantity over 90% were removed on the day of piscicide application (Munro, 1957).

Rotenone is universally used in the United Kingdom because of its good qualities. It has been declared easy and safe to apply by many users and it is said to decompose to a non-toxic condition spontaneously. It is also found not to affect other biological organisms, to be unaffected by temperature and considerable changes in water chemistry and quality (Everhart et al, 1975). But, Morrison and Struthers (1975) noted some side effects of rotenone on the invertebrate fauna of three Scottish freshwater lochs - Kinardochy, Choin and Cruinn. They noted some dead tadpoles, gammarus and larval newts in Loch Cruinn a day after rotenone application. It was also observed that the populations of cyclops, Diaptomus sp. and daphnia after the application of rotenone in the lochs, dropped and took varying length of time to recover.

Although rotenone is harmless to warm-blooded animals and stocking can safely be carried out within a few months of treatment, its use is practicable only in isolated bodies of water and waters whose connections to other water systems can be effectively blocked to avoid contamination and prevent fish recolonisation. Derris extract can be applied in liquid form or as a powder.

Where no damage is likely to occur, the dosage could be doubled or a repeat treatment could be made as done in most Scottish lochs (Lochs Cruinn, Choin and Kinardochy) by Morrison and Struthers (1975).

Selective removal of predators by use of chemicals could be hard. Some species of fish can show very weak resistance to low concentrations of chemicals which could otherwise be sub lethal to others. They exhibit low ability to survive indefinitely under a given set of circumstances. Others respond by avoiding or flight reaction before loss of equilibrium develops. Like in Loch Fitty, rotenone application was mostly intended for the removal of pike, but trout (about 0.2 tons) was also affected.

Rotenone is poison and the use of poison in inland waters is illegal in the United Kingdom. It contravenes the Salmon and Freshwater Fisheries (Protection) (Scotland) Act 1951, the Rivers (Prevention of Pollution) (Scotland) Act 1951 and 1965 and Salmon and Freshwater Fisheries Acts 1923 and 1975 and Rivers (Prevention of Pollution) Act 1951. (See Chapter 4.3.1 and 2). However the use of poisons could be allowed for removing of fish from waters if it is done for research and management purposes, provided necessary precautions are taken to prevent contamination of other river systems and protect life and other interests in those waters. In Scotland, before an application of chemical e.g. piscicide is made on any of the inland waters, permission of local Rivers Purification Board or the Fishery District Board of the area must be sought. In the absence of these authorities, permission is required from the person holding rights for fishing for migratory fish in the water. When permission is given, the Secretary of State for Scotland contacts the Freshwater Fisheries Laboratory whose staff may be required to carry out the work or supervise the application of the chemical. In England and Wales, permission is sought from the Water Authorities.

Similarly the use of nets, other than net and coble, electro-fishing gear and any other gear not legally allowed in inland waters for migratory fish is contrary to the Salmon and Freshwater Fisheries Acts. Such uses must be for research and management purposes and must be preceded with permission from the appropriate authorities.

The otter and mink have been hunted and trapped for several years while the birds such as cormorants, heron, and shag have been shot to reduce their number and effects on fish population (Mills, 1967a). The food of these birds have been established to be mainly fish (Chapter 3.5). The bulk of fish making up their food seems to depend on the types of fish supported by the water in the area where these birds occur. From the examination of the stomach contents of 147 goosanders and 148 red breasted mergansers from Scottish waters, Mills (1962) observed that young salmon mainly constituted 53% - 86% of the fish eaten, the whole year round.

To avoid or reduce this high depredation on commercial fish stock, reward (bounty payments) was offered by a number of District Fishery Boards for the destruction, by shooting, of fish-eating birds like goosanders. Although Jackson (Mills, 1962) feared extinction through this method, the birds do not seem to be under control yet despite the shooting. Elson (Mills, 1962) considers that such casual shooting of predatory birds cannot affect control rather a systematic way should be planned to extend the control all year round.

Predatory bird shooting for payment is guided by such principles that all participators are restricted to the sites of predation.

The principle of bird shooting could run contrary to the Protection of Birds Act and the ideals of the Royal Society for the Protection of Birds (R.S.P.B.) (Scottish branch) which is all out to safeguard the future of many thousands of birds. In the pursuit of this objective the R.S.P.B. has bought places e.g. 1666 acres Orkney, Moorland, Loch Garten+ at Speyside and Fowlsheugh in Stonehaven (Scottish Birds, 1976). These areas are declared sanctuaries under the "Save Places for Birds". Birds, unqualified, include predatory ones as well. Fishery waters within sanctuaries are therefore likely to suffer the effects of predatory birds that have acquired immunity from shooting by their presence within the sanctuaries. That problem of conflict of interest is obvious for while attempts are made to protect fish from depredation by birds by reducing their number, the R.S.P.B. is on the other side fighting to prevent harm to the birds. Such conflicts are not uncommon where diverse interests exist.

Linlithgow Loch is a typical controversial area. The loch is a fishing water and at the same time a bird sanctuary. While bird watchers and Scottish Wildlife Trust are after the protection of cormorants and other birds in this sanctuary, anglers are asking for the control of the cormorants. Anglers (of Forth Area Federation) and arguments for control of cormorants have estimated that a loss of about £800 was suffered by the Forth Area Federation of Anglers in 1970 due to predatory action of cormorants on trout. Basing their calculation on the supposed rate of predation on trout, they

+ Loch Garten sanctuary protects the ospreys which are rare birds in the U.K. They are also fish predators, taking most of their prey from the loch have also estimated that the cormorant takes even more than is stocked in the loch plus the fact that the feeder burns to Linlithgow Loch do not support, to any extent, the natural reproduction of trout (Ramsay, 1971). In agitating for cormorant control (Herd: 1971) declared:

> "I accept that people like to see cormorants. Nevertheless the cormorant problem could ruin the potential of Linlithgow Loch as one of the greatest fisheries in Britain......"

Despite the objections, the Scottish Wildlife Trust stands virtually in complete defence of the cormorants and sees the anglers' protests as a false cry of the presence of wolf.

Damage to fish and fisheries by grey seals prompted the Scottish Salmon fishermen to call for protection against further depredation. But as the fishermen called for control of grey seals, several oppositions and claims were made in certain quarters by some individuals. They claimed that the grey seals neither constitute a threat to salmon stock nor do any damage to fisheries, since they feed on diseased and weak fish and on predators of young salmon, and that the fishermen and the Government Departments concerned just wished to have seals exterminated. These claims were disproved by Rae (1960, 1968) and Rae and Shearer (1965).

Killing of seals by hunters was permitted but towards the last century the development of modern firearms led to over exploitation and a serious decline in seal number. Because of the threatened extinction, total ban on seal hunting was imposed. The grey seal population then grew and reached extremely high levels of about 40,000 in British waters by 1974 (Salmon Net, No.X, 1975). Damage to fish and fisheries increased and the need for their control was evident. The killing of those seals which learnt to damage and rob nets or to hunt fish cornered by nets was concentrated on.

The Grey Seal Act allowed rifle-shooting by licensed hunters but banned the use of the poison strychnine which was formerly allowed. The Seal Act however would permit the use of a poison which would be humane in its action and not liable to kill people or domestic animals. The Orkney breeding colony of grey seals is now being cropped by licensed hunters under government supervision. This yields up to 1000 pups (permitted limit) per year. Licensed cropping is also allowed on the West Coast of Scotland.

In Nigerian waters, fish predators include predatory fish e.g. Nile perch - Lates niloticus, the characids (Hydrocyon forskalii, H. lineatus); the snout-fish - Gymnarchus niloticus and Synodontis sp.

Predatory birds include kingfishers, ducks, fish-eating eagles, and some other fish-eating water birds. Reptiles like water snakes, crocodiles, alligators and turtles also predate on fish.

Man tops the list of predators for his indiscriminate ways of removing fish from the waters (Chapter 3.4).

Predator control in Nigerian waters is not really done on an organised basis i.e. involving the government and authorised bodies. The obvious reason is that the existing Wildlife Protection Act which is almost defunct, is neither observed nor strongly enforced. Individual control of predators is usually the case.

Fish in reared conditions are protected from predators particularly birds by flying of brightly coloured pieces of cloth (as observed in some countryside crop farms too in Scotland) and clattering of native gongs to strike terror into the invading birds and drive them away. Use of wire netting above the farms may be too expensive for a local farmer. Secondly the perambulatory nature of most of the predatory birds make the wire nettings ineffective. Alternatively paid human labour may be employed to keep watch over fisheries establishment to ward off the greatest of the predators - man - whose poaching activity can ruin the establishment.

In the wild, predator control is usually for a dual purpose. It is done to protect the fish and to procure the predator e.g. bird, crocodile or turtle for food and their feathers, leathery skin and skeletal shell respectively which are of commercial value.

It might be a good idea to speculate on what the situation would be if bounty payments were made to Nigerian hunters for eliminating freshwater fish predators as was done in Scotland for the predatory birds - goosander. In the first instance most Nigerians in the countryside would turn hunters overnight so as to earn the bounty payments. Secondly random killing of wild life would result irrespective of their role in predation. Thirdly 'hunters' might not be honest enough to restrict their hunting activity within the predators' zone of activity. In the long run any Acts passed to protect Nigerian Wildlife would be ineffective for little or nothing might remain to be protected and natives still acting under the guise of bounty payment system might continue to track down wildlife.

Bounties were paid for wild dogs, baboons and jackals in Botswana (Riney & Hill, 1967). This was found to be inefficient and did not live long as it was short-lived in some other African countries. In Zambia the bounty payment system was also dropped and a new system of predator control initiated. Members of Game Reserve worked with authorised hunters who are permitted to shoot the animals assigned to them. These hunters are only to shoot in the vicinity where damage is done and not to follow predators beyond three miles limit (Riney & Hill, 1967).

It is obvious therefore that the system of bounty payments would not help in solving any predation problem in Nigeria. The greatest predation on freshwater fish in Nigeria, is from man and not wild animals that have got enough to live on.

4.2 RESOURCE DEVELOPMENT

4.2.1 RESERVOIR DEVELOPMENT AND ITS EFFECTS

Reservoir development has led to impoundment of flowing water with the purpose of providing water for domestic uses, industries, power generation and irrigation. At times reservoirs may be used for flood control. In many cases apart from the primary purpose, an integrated series of benefits are projected that include transportation improvements, recreation facilities and fisheries. As large impoundments develop the tendency for commercial and sport fisheries establishment in them increases.

Where salmon and sea trout abound as in some Scottish rivers, reservoir development can involve some problems, partly because of the need to provide both for the upstream movement of adult fish and for the downstream movement of smolts going to the sea in the spring. If sufficient water is discharged through the dam at all, or nearly all times, it is possible to provide fishpasses up which adult fish can go reasonably easily and in which the annual run could be counted.

There are three major impoundments on the Tweed catchment area in Scotland. These are the Whitadder, Fruid and Talla reservoirs. The fourth - the Megget is proposed and already on plan.

The Fruid Reservoir completed in 1967 was established to meet the water demand for Edinburgh. The water from the high altitude reservoir goes to the storage reservoir in Liberton and thence supplied to Edinburgh. Mills (1971), noted that the absence of a fishpass on this reservoir led to loss of spawning ground upstream. However the need for a fishpass is not so strong since the spawning ground is small and can only take a few fish. To avoid the engineering problem and the financial expenses in incorporating a fishpass where it is of little benefit, it has been decided that the stock of fish in the reservoir could be better supplemented through hatchery reared fish. For the loss of spawning ground, compensation was paid out by the Edinburgh Corporation to the River Tweed Commissioners in-charge of the catchment area. For the benefit of fisheries below the reservoir, a compensation flow of the two-thirds of the average daily flow was agreed on in summer and in winter only one-third of the average daily flow.

The Talla reservoir which is much older than Fruid also lacks a fishpass since it was uneconomic to instal one in the dam for the same reason as Fruid. The reservoir is for domestic water supply and like the other reservoir - Fruid - it releases its compensation water downstream for the migratory fish e.g. sea-trout that usually frequent this tributary of the River Tweed.

Apart from the access to spawning ground, reservoir development can also cause flooding of spawning grounds for fish. This is one of the problems to be encountered in the proposed Megget Reservoir. The Megget Reservoir is planned to supplement the water supply to Edinburgh and suburbs. On completion of the reservoir, it would be over 4 km long with an area of about 267.3 ha at the spill-way level. About 13 km of stream with varying width of 2 meters to 20 meters would be lost as salmon producing area after inundation and about 8.4 ha of stream-bed suitable for spawning will be deprived salmon and sea trout (Osborn, 1972). In the instance, financial compensation has been paid by Edinburgh Corporation to the River Tweed Commissioners for the losses to be sustained.

The fisheries problem apart, the planned Megget Reservoir, from observation of the extent of the site to be covered, will cause some economic and social problems. Pastures and agricultural land are to be flooded when it is full. An existing road which is currently being used will also be flooded. This entails construction of a new road for transportation and communication. Socially the countryside farmers within the inundation site will be displaced from their homes and compensation paid them for loss of pastures, agricultural land and farm houses. The effects on the environment of reservoir development either for water schemes (Chapter 3.2) or hydroelectricity (Chapter 3.3) as in Scotland, however, have been discussed earlier.

Many reservoirs like Thruscross, Swinsty and Damflask among the reservoirs I visited in the Yorkshire Water Authority area in England, serve multipurpose functions. These reservoirs like those in Scotland supply water for domestic uses and industry. Thruscross Reservoir supplies domestic water to Leeds and releases compensation flow of about 2 million gallons daily. Swinsty, Plate 4, was badly affected by drought probably because of the highly prolonged hot weather and less rainfall in 1975-76 (Shillcock, personal communication). Damflask Reservoir in Bradford supplies water to Sheffield and some of her industries.

Like the Fruid Reservoir in Scotland, angling is allowed in these reservoirs. Furthermore water recreation and sports like boating, yachting, are allowed in some of the reservoirs e.g. Damflask, Plate 5.

The Morehall and the Underbank Reservoirs are mainly for domestic water supplies. Underbank supplies water to Stockbridge and releases a compensation flow of 30 million gallons weekly.

PLATE 4

Swinsty Reservoir in Yorkshire affected by drought.

PLATE 5

Damflask Reservoir in Yorkshire showing a yachting depot on the farside.

While the two reservoirs are stocked for the benefit of anglers, they do not allow other water recreations. Morehall is mainly a trout reservoir while the Underbank like Damflask support trout and coarse fishing. (J. Hick, pers. comm.).

Since the rivers on which these reservoirs are established do not support migratory fish, the need for fishpasses in their dams has not arisen. The sport fisheries supported by these reservoirs are mostly supplemented through artificial propagation.

Fishery Potential of Reservoirs: Every impoundment has a fishery potential either negative or positive in comparison with the situation before the impoundment. Where future potential seems negative, particularly in waters where migratory fish e.g. salmon are present, extensive research to minimise the adverse effects of the project on fisheries should be carried out. It is indeed fortunate that the factor of future fisheries is seriously considered these days by those responsible for any new impoundments and maintenance of existing ones.

Migratory behaviour of fish and spawning can be impaired by reservoir development. With reduced flow and insufficient compensation water below the dam, migration can be prevented.

Fish show adaptation to their environment and with changes caused by reservoir, this change from a lotic to a lentic environment could seriously affect the fish stocks and a gradual decline of the population of certain species may occur, while others better able to adapt to a lake environment may increase. Where an introduction of exotic species is necessary to build up the fish population it should be done with caution to avoid any unanticipated problems of competition, predation or disease spread. Newly formed reservoirs usually have high primary production and adequate supply of food to fish but when this initial high primary production declines, the fish usually show poor and stunted growth because of insufficient food supply (Campbell, 1963). For example in the Fruid Reservoir, better growth of trout was noted because of the high food supply provided by terrestrial organisms initially but as it became low, poor growth of trout resulted.

Eutrophic conditions of impoundments can cause ecological succession amongst plant and animal communities and also make the development of a particular fishery difficult. For example the loads of phosphate and nitrate from East Midlands pouring into Grafham Reservoir has made the development of trout fishery in this reservoir by the Anglian Water Authority to be difficult (Fleming-Jones, 1974). These mineral salts have so enriched the water, causing alga bloom and massive production of macrophytes in summer. This condition favoured the invasion of the reservoir by coarse fish such as pike and perch. The perch reproduced profusely and nearly caused the extinction of brown trout in the reservoir even though the trout depredated on the perch. On the other hand pike depredated on the trout thus helping to reduce the population more (Fleming-Jones, 1974).

Where there is a potential for positive fisheries, high yield could be achieved through proper planning even though the reservoir might be primarily for hydroelectricity or irrigation.

Nigeria's Kainji Reservoir which covers an area of about 500 sq. miles has its economics based on multipurpose development of the lake for improved navigation, agriculture and fisheries as a subsidiary to electricity production.

It could be said that better prospects exist for reservoir fisheries in the tropics because of the climatic, physical and biological factors prevailing. The characteristic tropical climate, intermittent heavy rainfall with the ensuing flood and high temperature, could bring about quick changes in the features of reservoirs. The resulting changes associated with aquatic vascular plants offer a favourable habitat to tropical fish (Jackson, 1960).

Many tropical fish such as Tilapia spp. Cyprinus spp. and Clarias spp. use sheltered and semi-stagnant areas of rivers to spawn and reproduce. The development of dams invariable enlarges the number of favourable spawning grounds for such species of fish. Increased food supply is provided for fish due to eutrophication. Better protection from predators is also given by the plants while more spawning substrates (plants) are made available to those fish that spawn on plants. This state of improved condition may enhance the survival of the newly spawned fish. The age structure of the population is bound to change due to high survival rate of the young fish spawned after inundation (Jackson, 1960a). Within a comparatively short space of time, a fresh population equilibrium at a higher level than in the past is reached in the water. This was the way in which the carrying capacity of Clearwater Lake, Missouri, was reached five years after inundation, Patriarchie (Jackson, 1966).

There are, however, adverse side effects which could mar the benefits of reservoirs in the tropics. These effects which result from the changing face of the river basins affected have led to problems - ecological, medical, sociological and other human problems associated with reservoir impoundment and resettlement of the displaced.

Ecological: Changes in the flow regime, physical and chemical qualities of the water have led to ecological succession in plant and animal communities. Plant invasion of the new lacustrine habitat as observed in most African man-made lakes e.g. Kariba (Jackson, 1960a), Volta (Hall et al, 1966) and Jebel Auliya (Little, 1966) as discussed in Chapter 3.6 cause some economic losses.

Medical: Cases of widespread schistosomiasis in Egypt and opisthorchiasis in South east Asia (Dasmann et al, 1973), onchocerciasis by Simulum damnosum in Kainji (Kershaw, 1966), filariasis, trypanosomiasis and malaria following water impoundment in the tropics, Lagler (Dasmann et al, 1973) have been reported. These diseases which are debilitating have caused a public health hazard and losses in worker productivity. They contribute to high mortality in infants and adults and miscarriages due to high parasite levels in the blood.

Disease problems associated with population movement is common too. Movement of infected populations to new areas may cause the spread of parasitic and communicable infections to the new area and its population. Similarly uninfected population may be concentrated in new disease foci where there is a high probability of infection.

Sociological: Resettlement after reservoir construction may often involve major changes in traditional land use patterns and possibly in a communities diet. This may be particularly true where lowland agricultural patterns on alluvial soils have to be replaced by those appropriate to upland and non-alluvial sites. These land relocations can lead to the abandonment of former land use practices and crops. A change in the nutritional status which may be impoverishing due to inability to adapt to new agricultural practice may result. Also lack of easily available food which the community is used to, and the inability of the poor soil condition to sustain intensive long-term agriculture for a rich harvest may result in poor nutritional status of the population.

A further problem may arise when populations downstream of the reservoir site become adversely affected by altered water regimes which affect fishing and loss of soil nutrients from seasonal flooding which affect agriculture. For example since the establishment of the Kainji Dam (Nigeria) in 1968, the fishermen along the Niger south of the dam have complained of very poor fishing (personal communication). It has been observed, also, that the usual flooding pattern of the Niger south of the dam has changed, resulting in very reduced flood during the rainy season that lowland agricultural crops (swamp rice) are badly affected. At Kariba, Scudder (1972) noted that intermittent releases of high and low quantities of water uncorrelated with former natural discharge patterns made traditional agriculture and fishing in the downstream river basin difficult and impractical. He concluded:

> "I am not aware that those planning for Kariba even considered alternate outflows for the future development of the downstream area. Nor am I aware that they considered the costs of possible food shortages arising from the present regime......."

From numerous studies of population displacement and resettlement resulting from reservoir development, about 80,000 people were settled in Ghana because of the Volta Dam project, 120,000 in Egypt and Sudan because of the Aswan High Dam and Jebel Auliya respectively; 42,500 in Nigeria as a result of the Kainji project and 25-30,000 in Thailand (Dasmann et al, 1973).

At times resettlement plans fail because of cultural and traditional differences existing between the displaced and the new environment. To avoid such situations, preventive planning, ecological, sociological and comprehensive preinvestment studies carried out in advance will help to improve the living conditions of would-be displaced people of a river basin. Such studies will also help to forestal problems arising from reservoir development which may disrupt other national projects and developments.

4.2.2 FISH FARMING AND ITS ROLE

Farming of fish (fish or shellfish) is an aquacultural practice aimed at achieving high fish growth and production for food primarily through the provision of favourable conditions. Successful fish farming demands sufficient management techniques involving hatchery operations where possible and a high standard of hygiene to prevent disease and parasite infection.

Fish farming is useful in the improvement of natural stocks through artificial recruitment, hybridization and transplantation. It also serves for the production of ornamental, sport and bait fish and trash fish for fish meals.

A variety of methods e.g. tanks, cages, raceways, ponds and recirculatory water systems are used in fish farming. However pond culture continues to be the main method in many parts of the world.

There is that increasing awareness of the need for fish farms in the United Kingdom and the fish farmed in significant quantities is the rainbow trout, Salmo gairdneri. About 150 farms estimated to be in operation, produce between 1000 - 2000 tons of rainbow trout yearly (Solomon et al, 1975). These figures which are rather low, would not compare favourably with the rates of development of other natural resources and sectors of agriculture. The probable reasons for this slow pace of development might be:

(1) Non-dependence of the public on freshwater fish, while much attention is drawn to sea fish for food. It was observed that out of the £300 million a year spent by British housewives on fish, less than one percent of the fish is from British freshwater stock. This one percent was mostly trout (Freemann, 1977).

(2) The demanding nature of trout in culture has created problems of siting and a clean and well-oxygenated water supply. The latter problem is aggravated more by pollution and multiple use of water by the ever growing population. But modern developments like recirculation and oxygenation systems seem likely ways of circumventing these problems, as is being developed by the Shearwater Group of the British Oxygen Company (B.O.C.).

(3) There is the genetic problem; the need to produce such strains of rainbow trout that mature without much delay, grow fast and produce enough for commercial cultivation and that which adapt to water conditions of the area.

(4) The occurrence of diseases like Infectious Pancreatic Necrosis and viral diseases and their identification and practical treatment constitute a problem to fish farms.

(5) The problem of food and feeding. The cost of supplying protein rich ration to fish is high. Investigations are therefore underway, by government scientists, to identify sources of protein other than fish meal (Scottish Fish Farming Assoc. Newsletter, 1976) for the benefit of industries.

(6) Climatic conditions are also a limiting factor in fish farming. The low autumn/winter temperatures impair feeding activity and contribute to slow growth of fish. Because of wide variations in temperature, the time-cycle for trout production is 18 months in the North (Scotland) which is colder, while in the south it is only 10 months (Solomon et al, 1975). The growth of coarse fish is also affected by the low temperature. However experiments are underway for heated water in rearing of coarse fish such as roach in Essex by National Anglers' Council.

(7) Because of the afore-mentioned problems, high investment may be required to set up a worthwhile fish farm in the United Kingdom and market availability must exist for the products. Unfortunately the question of subsidies for fish farming and marketing cooperatives has not been successfully settled as in other E.E.C. countries. This has helped the fish farming problems in the U.K. and the product marketing difficulties both in the U.K. and in the continent. Also competition from other subsidised farm products and the dumping of low priced Japanese products have worsened the market condition of the U.K. fish farm products.

Establishing a fish farm is one thing and running it effectively is another. Owing to some unpleasant aspects mentioned below, fish farms do not hold much enthusiasm for their workers and lack of enthusiasm can lead to unsteady staff, employment of untrained hands and slow rate of development.

(1) The problem of housing. Many fish farm sites are remote and isolated and with little suitable housing in the vicinity. Where a house is provided the fish farm worker is not covered by the legislation - Tied Cottages - Rent (Agriculture) Act, which gives agricultural workers in tied cottages security of tenure. This is so because aquaculture is not yet regarded as part of agriculture though the battle is on in the House, to bring aquaculture under agriculture. If the amendment to the Agriculture (Miscellaneous Provisions) Bill which incorporates aquaculture, goes through, aquaculture will have to derive the same benefits of rating and grant aids as agriculture.

(2) The fish farm tasks which are enjoyed during the summer days are very unpleasant during the winter periods because of the cold weather.

(3) The arduous task of tending fish for seven days a week does not give room for leisure.

(4) Job security: This may not be guaranteed, particularly if farms have got to be closed down because

of serious disease outbreaks, with loss of stock leading to bankruptcy.

Scotland: Despite these problems the number of fish farms in Scotland is still growing with an increase in production of both salmon and trout. In a recent survey, the Department of Agriculture and Fisheries for Scotland - D.A.F.S. found the size of the fish farm industry in Scotland by 1975 to be as follows (Scot. Fish Farming Ass. Report 1976).

30 Freshwater Rainbow Trout Farms

8 Saltwater Rainbow Trout Farms (sea cage units)

5 Put and take trout Units

6 Atlantic Salmon sea-water on-growing units

1 Experimental fish farm (Commercial Consultant)

There are about 72 salmon and trout 'stocking' hatcheries and 9 commercial salmon smolt hatcheries. A smolt rearing station at Montrose is shown in Plate 6.

Fish production (tons) from these industries had been thus between 1972 and 1975.

	Production (tons)		
	1972	1974	1975
Rainbow Trout	340	594	approx. 700
Atlantic Salmon	20	50	" 80

(Scot. Fish Farming Assoc. 1976)

Marine culture is not reglected. Over forty sites are leased from Crown Estate Commissioners for oyster, mussel and other shellfish culture. Marine flat fish are also cultured. Three research groups - White Fish Authority - W.F.A., Fitch Lovell and British Oxygen Company in Ayrshire are cultivating Dover Sole and Turbot. White Fish Authority noted that with the potential existing in marine fish farming in Scotland, about 50,000 tons per annum of Turbot in pens in sea lochs and 2,000 tons per annum of Dover Sole could be produced.

Progress of fish farm industries and the communication between them and the Government is fostered by an Association like the Scottish Fish Farming Association - S.F.F.A. The S.F.F.A. is responsible for legislative matters that involve all types of fish farms and membership to this Association is open to all fish farm industries. The Association liaises between the industries and the Government on policy and legislative matters affecting fish farming. As a go in-between the S.F.F.A. through her representations to DAFS, has fought for some statutory amendments in fishery laws to exempt fish farms from some of the clauses of the Act. By the Freshwater and Salmon Fisheries (Scotland) Act 1976, recognition was given to fish farming by the lifting of the close season ban on farmed salmon.

The question of the Derating Act which affected fish farms in Scotland is vigorously looked into by the S.F.F.A. but meanwhile there seems to be no immediate solution. Since this law relating to rating of fish farms, has not proved useful to farmers, the SFFA has pressed for its clarification. A number of farmers who have had experience with the rating authorities are ready to protest and let others know of their feelings.

PLATE 6

Salmon smolt rearing tanks at Montrose.

PLATE 7

A part of the trout hatchery at the Calverton trout farm of the Severn Trent Water Authority.

The Association's request to DAFS for permission to shoot herons in order to protect fisheries from predation was not granted, since the Department of Agriculture and Fisheries for Scotland is not responsible for the Protection of Birds Act in Scotland.

In 1975 huge egg import regulations were introduced and these did not favour the fish farm industry. The Scottish Fish Farming Association objected to these and the regulations were eased off thus enabling the Association to continue their egg import from accredited Danish sources. Despite this relaxation and the lifting of the close season ban on farmed salmon, the movement of salmonid eggs was strictly in keeping with the Diseases of Fish Act 1937 (See Chapter 4.3.5) to ensure that no disease infected eggs are imported into the U.K.

The Fish Farming Committee of S.F.F.A. is its scientific branch which has the responsibility of reviewing the whole field of fish cultivation, examining its research requirements in relation to the future potential of the industry, and consider to what extent these are being met by existing research and make recommendations.

The Committee is very much interested in rainbow trout diseases: their identification and treatment; nutrition - developing sources of protein other than fish meals and rearing work in saltwater. The Committee is also interested in rainbow trout genetics to find a way of achieving fast growth, avoid delay in maturation and produce enough stock that can adapt to the local water conditions.

Among other bodies that foster the activities of fish farm industry in Scotland are: the National Farmers Union (Fish Farming Section) Scottish Branch, Salmon and Trout Growers Cooperative and the British Trout and Salmon Marketing Association - B.T.S.M.A.

The Salmon and Trout Growers Cooperative are responsible for more commercial matters that are of specific interest to their members e.g. marketing survey, cooperative marketing etc.

The British Trout and Salmon Marketing Association - B.T.S.M.A. is aimed at assisting table trout and salmon farmers in Britain to produce and market their products more efficiently by providing services including market intelligence, advice and publicity. Members of this Association include: N.F.U., Fish Farming Committee, Scottish Trout and Salmon Farmers Cooperative and Northern Ireland Trout Farmers Association.

England and Wales: Despite the climatic advantage of warmer weather England and Wales have over Scotland, less than 0.1% of the water industry's manpower in England and Wales is at present employed full time in fish farming (Freeman, 1977).

Since the English and Welsh water industry was reorganised in 1974 and the nine English Water Authorities and the Welsh National Water Development Authority found themselves responsible for fisheries according to the Water Act 1973, they have taken the task of restocking rivers and reservoirs for conservation and replacement of fish stock and for the benefits of licence-holding anglers. The water authorities have given some thought not only to trout production but to the possibility of providing coarse fish through cultivation.

Currently about 24 fish farms are run by the water authorities in England and Wales. Table 13 gives about the number in each water authority area. Most of the farms, of which some are in the experimental stage, are for coarse fish (Freeman, 1977). Most of the water authorities have additional units such as hatcheries and cage rearing sites to 'straightforward farms'.

Table 13. The number of fish farms run by each Water Authority in England and Wales

Water Authorities	No. of Farms+	
Anglian	4	Mixed (Trout and coarse fish farms)
Northumbrian	3	Trout
North West	2	
Severn Trent	1	Mixed
South West	2	
Southern	2	Mixed
Thames	1	Trout
Wessex	4	Mixed (Trout and coarse fish farms)
Wales	4	
Yorkshire	1	Trout

+ These are 'straightforward fish farms'. Carp, Tench and Roach form the major fish cultured in the coarse fish farms.

From the rate of coarse fish farm development it is evident that the south (England and Wales) is leading the north (Scotland) in coarse fish production. Scotland concentrates more on salmon and trout.

During my field trips in the course of this study, I visited the Severn Trent Water Authority and its fish farm at Calverton (Appendix - Trip 5). This farm was inherited from the old Trent

PLATE 7A

Egg-trays with trout eggs and some hatched-out alevins at the Calverton hatchery.

PLATE 8

A section of the trout farm at Calverton. Note the gravelly bed of the ponds.

Fishery Board (Alan Starkie, pers. comm.) and was intended for coarse fish. But the water being unsuitable, attention was turned to trout. By late 1975 coarse fish particularly carp were reared in the farm. The farm which covers an area of about 3.2 ha. also has a hatchery (see Plates 7,7A & 8) attached to it. The estimated cost of running this farm is about £21,000 and the farm's income derived mostly from trout rearing is about £25,000 (Freeman, 1977).

About half of Calverton fish farm is now rearing trout from egg stage to the takeable size of more than 36 cm. The other half of the farm is devoted to experimental rearing of coarse fish. The water is conditioned with cow manure to encourage natural plant and animal life and make it more acceptable to coarse fish. The farm is also looking into the possibilities of maintaining a warm environment for the fish, to encourage fast growth and early spawning, by building simple green houses over the ponds or by use of solar heat. The Central London Polytechnic which is involved in this project, is providing the solar panels while Calverton farm provides the fish and site.

The Yorkshire Water Authority which I also visited runs a trout farm of considerable size at Pickering in addition to an experimental coarse fish farm. The trout farm established in 1948 has an estimated output of 100,000 fish (90% brown trout and 10% rainbow trout) annually (Water Space Amenity Commission, 1975). Plates 9 and 10 show parts of the fish farm at Pickering. Each year the angling clubs within the Pickering zone and in the Yorkshire Water Authority area advise the Water Authority on how many trout are required. From the farms, the anglers' requests for disease-free trout to be introduced into the rivers and reservoirs are met.

PLATE 9

Fry tanks being attended to at the Pickering Trout Farm - Yorkshire.

PLATE 10

A part of the trout farm at Pickering in Yorkshire Water Authority area.

The National Anglers Council in cooperation with the Anglian Water Authority, Cooper Nutrition Products and Essex Water Company set up a pilot fish rearing unit at Langford in Essex. This unit aims at intensive roach rearing by trying to overcome the problems of growth being restricted to the summer months and the disease susceptibility associated with the fish. It is also intended that induced spawning should be adopted at a high level with a view to obtaining the best possible strain and enough brood stock.

The Water Authorities in keeping to the Diseases of Fish Act 1937, adopt certain procedures before fish are moved from one source to another in order to prevent disease and parasite spread. Basically the water authorities require:

(i) About 14 days notice of movement in writing from purchasers.

(ii) Liaison with colleagues in area of farm of origin for background information.

(iii) Carry out visual inspection of fish or rigid virological and bacteriological examination where possible before the fish are moved out and allowed to enter the water in their area.

As in Scotland, the National Farmers Union - Fish Farming Section also operates in England. It holds meetings and co-operates with National Water Council and the Fisheries sections of Water Authorities in matters of mutual concern particularly in the movement of fish and disease control.

One may ask to know what the fate of fish farming has been all along and the role of fish farming in a nation. Fish farming received very meagre attention in the past. Probably because it looks a traditional practice that even the most modern fish culture installations cannot give it the attractive image of modern industrial developments. Traditional, social and political reasons could be contributing factors for the meagre attention. Lack of appropriate economic evaluation also could have basically hampered its development.

But despite the odds, fish farming is increasingly playing vital roles in the life of a nation in particular and the world in general. It is a source of food supply. In the Far East e.g. China, fish farming contributes at least 40% of the total fish production; 38% in India and 22% in Indonesia (Pillay, 1973). In Africa its contribution to food, though it is helpful, is yet to be measured since it is still in the developing stage. The world production of fish for food through fish farming is about 5 million tons (Pillay, 1973). Of this quantity fin fish alone contributes 3.7 million tons while 1.3 million tons are contributed by shell fish, molluscs etc.

In resource and economic development fish farming can make a remarkable contribution. Milk fish culture alone contributes about $20.5 million to the United States and at the same time provides employment for about 500,000 people (Pillay, 1973). In Japan the scale of fish farm production is quite astonishing for it provides 16% of the nation's economy. In the United Kingdom the Unilever Research Laboratory alone produced about 20 tons of rainbow trout worth £10,000 in 1967, 47 tons in 1968 and 85 tons in 1969 (Mills, 1971). With the increase in the number of salmon and trout industries particularly in Scotland, it is likely that the scale of farmed fish production and marketing will increase to the benefit of the nation's economy.

Large quantities of trash fish can be produced through fish farming. These low grade fishery products are converted into high quality fish by their efficient utilisation in fish farming. On the other hand fish farms can be devoted for production of low grade fish for conversion into fish meals for human and animal consumption.

Imaginatively planned and intelligently applied fish farm can provide a means of revitalising rural life and of supplying products of high nutritional value to urban dwellers. Farms established on large scales can require intensive labour. In the developing countries where farm operations are not fully mechanised, employment potential will be high for rural dwellers.

Fish farming provides an intellectual challenge to skilled professionals of many disciplines and is a rewarding activity for farmers and other workers at many levels of skill and education.

It helps to supplement conventional fisheries and does not pose as a challenge to commercial fishing (whether in the river or sea). Similarly culture fisheries give no cause for international conflict as the high sea fishing can, since the farming is done within a country's national boundaries.

Variability (size, age and species of choice) in production is met to satisfy the consumers. Ability to programme production, to meet the season's demand for sport fishing, make up for less catch in the adverse commercial fishing season and thereby stabilising market conditions also symbolise the beneficial role of fish farming. By breeding fish in captivity and under controlled conditions, opportunity is created for stock improvement through genetic selection of high yielding varieties.

Although some fish like the Chinese and Indian grass carp do not breed in captivity, spawning could be induced by use of hormones (Chaudhuri, 1976). Grey mullet, Chinese and Indian major carps have successfully been induced to spawn by pituitary hormone injection (Tang, 1964). The pituitary hormone extract which is got from ripe and mature male or female fish when injected can only trigger off fully ripe ovary to shed ripe eggs. Chaudhuri (1976) suggested a varying dosage of 2 mg/kilo to 12 mg/kilo at varying intervals (about 24 hourly in the temperate regions to 6 hourly in the tropics).

The right time for the pituitary hormone injection is after the fourth developmental stage i.e. prespawning stage. At this stage, the eggs are fully yolked and the fish can remain dormant for months until it is in contact with spawning stimuli. The injection, an artificial stimulus, triggers the development of the eggs to the fifth (final) stage.

In the non-breeding season the contents of gonadotropins in fish pituitary gland is small and of low potency. The potency of gonadotropins is high in the breeding season. Yashouv et al (Hickling, 1971) tested the pituitaries of common carp in Israel and found that their potency was high between May and August which is the breeding period.

In the tropical waters as in Nigeria, spawning starts about April/May to September/October though some species of fish like Tilapia melanopleura breed five to six times in a year (F.A.O. 1965). The majority of spawning activities generally coincide with the period of heavy rainfall which causes flooding and creates marshes, thus making available more favourable spawning sites.

4.3 LEGISLATION

4.3.1 FISHERIES (PROTECTION) ACTS

For over 800 years the United Kingdom has been conscious of her Fisheries which is one of her major renewable natural resources. All attempts were therefore aimed at protecting and conserving it. The protective measures which came as legislation, were mostly designed for salmon that have entered the rivers to breed.

In Scotland a statute law to protect salmon existed as far back as the time of David I in the twelfth century. From then to the present time series of Salmon Fisheries (Protection) Acts have been passed. It was the Salmon Fisheries (Scotland) Acts 1862 and 1868 that gave a strong framework and good working basis for the other Acts that followed. These Acts of 1862 and 1868 came up when the Salmon Fisheries Act 1828 (Scotland) - called Drummond's Act, failed to achieve satisfaction to the fisheries proprietors of upper reaches of the river because of the extended net fishing season and the short rod fishing season which allowed few fish to reach the upper reaches of the river before the season runs out. This Drummond's Act failed to give adequate protection to salmon and bred dissatisfaction because the lower reaches of the river had a better crop of the salmon.

By the Salmon Fisheries (Scotland) Act 1862, a body of commissioners charged with the responsibility of among other things fixing boundaries of Fishery Districts, and defining estuary limits was constituted. The Commissioners were also charged with the responsibility of determining dates of annual close time for each district, and make general regulations for the observance of the weekly close-time.

The District Boards to be formed are to be composed entirely of proprietors holding rights of salmon fishing. The maximum number on a board to be seven and the proprietor with the highest assessed rental acts as Chairman. The Boards which cover almost all the important salmon rivers have the responsibility of regulating local matters.

The Salmon Fisheries (Scotland) Act 1868 defined and extended the powers and duties of District Boards. The District Boards are empowered to purchase for the purpose of removal, dam dykes, cruives or other fixed engines. They have the authority to remove any natural obstructions or waterfall, attach fish passes where necessary and carry out those functions which are important for the protection and improvement of fisheries under their charge. On petition to the Secretary of State, the Boards can vary annual close time which must, however, be 168 days; vary weekly close time which must, also, always be 36 hours and can alter the regulations with respect to construction and use of cruives and weirs as may appear expedient to the local environment.

The Salmon and Freshwater Fisheries (Protection) (Scotland) Act 1951 lent force for salmon protection in the rivers. It stipulated rod and line, net and coble as the only method of fishing in inland waters. It prohibited the use of poisons, explosives and other harmful means e.g. spears and electrofishing, of taking salmon. It gave protection against poaching in any of the Scottish waters including the River Tweed.

This Act outlined the powers of the water bailiffs duly employed by the Fishery District Boards. The bailiffs are empowered to examine fishing equipments, ask for fishing rights and under suspicious circumstances can seize the equipment used and the fish caught. They have the right to prosecute a person for illegal fishing for salmon.

The Secretary of State for Scotland is empowered by this Act to collect trout and salmon catch statistics, Fig.11, for Scotland for the purposes of protection and development of salmon stock. There are, however, on confidential grounds, limitations on his power to publish the statistics collected.

River Tweed: The Tweed with its tributaries is regarded as a special area. It is a borderline river between Scotland and England and the most salmon supporting river in the United Kingdom. Because of these, it is governed by the Tweed Fisheries Act 1857 and Tweed Fisheries (Amendment) Act 1859, though it is also covered by the Salmon and Freshwater Fisheries (Scotland) Act 1951.

The administration of salmon fisheries in the Tweed basin, is the responsibility of the River Tweed Commissioners - a body of all proprietors of salmon fishings of annual value of thirty pounds or prescribed length of bank. There is no Fishery District Board for River Tweed as there are in other parts of Scotland. The Tweed Fisheries Acts 1857 and 1859 which came before the Salmon Fisheries (Scotland) Acts 1862 and 1868 empowered the Tweed Commissioners which it set up to manage, and protect salmon fisheries within the Tweed basin. The Tweed Acts are similar to other Fisheries (Scotland) Acts, the difference being in the administration i.e. formation of Tweed Commissioners for the Tweed basin.

The importance of River Tweed is emphasised by the extension of its mouth five miles seawards, seven miles southwards and five northwards by the Tweed Fisheries (Amendment) Act 1859. Within this extension fixed engines e.g. cruives are forbidden and fishing only

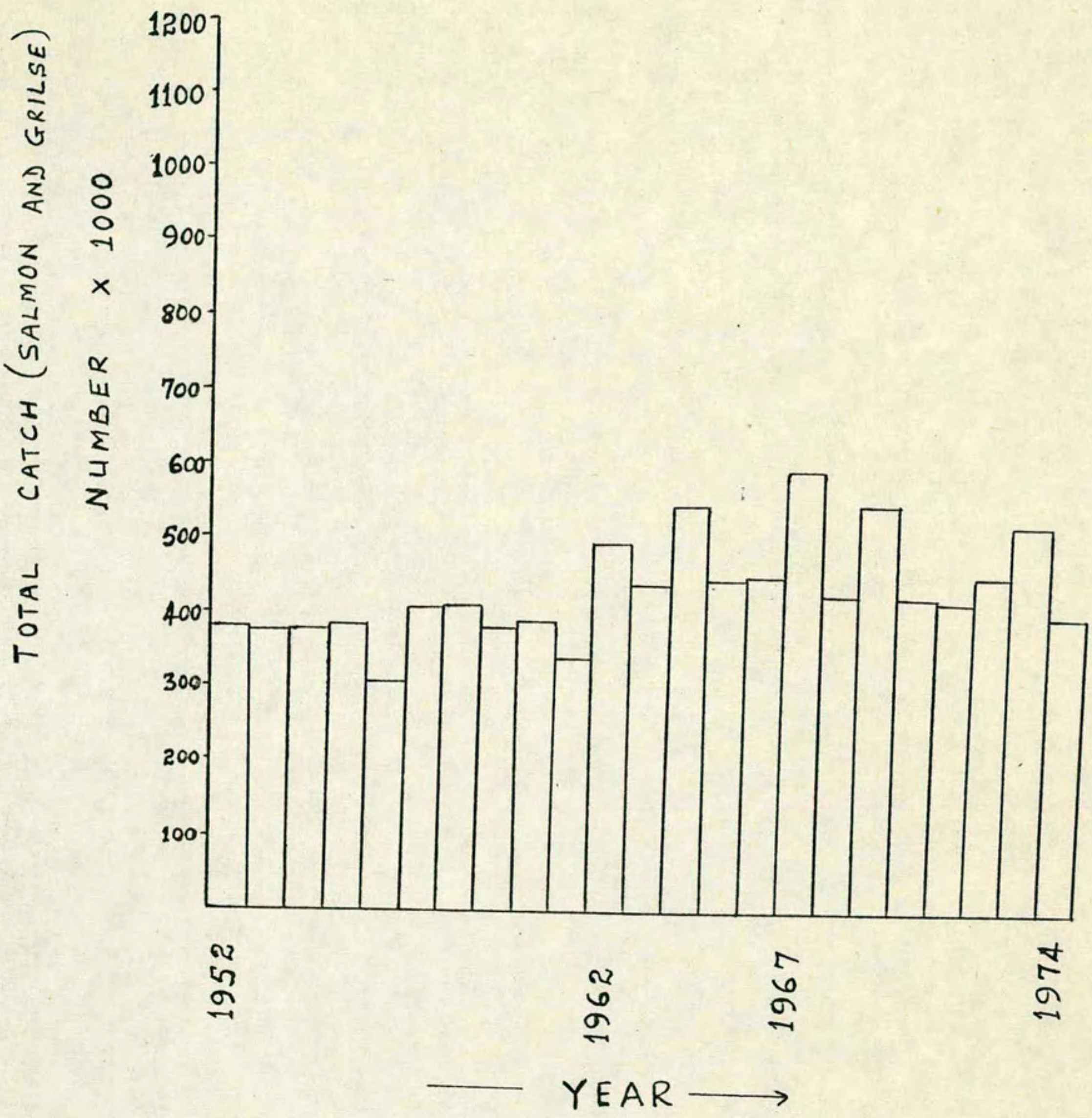


Fig.11. Total Salmon and Grilse catch by all methods for the whole of Scotland for 1952 - 1974.

confined to those with fishing rights. Salmon spearing was abolished by the 1857 Act and possession of spears within five miles of the River Tweed was declared illegal by Tweed Fisheries Act 1859. Other restrictions as to mesh size, obstruction removal, killing of spawned fish etc. as in the Fisheries Acts 1862 and 1868 for Scotland and in the Salmon and Freshwater Fisheries Acts 1923 and 1975 (treated later) also apply.

The annual close season for salmon and trout netting as fixed by the Tweed Fisheries (Amendment) Act 1859 lasts 153 days i.e. 15th September to 14th February. The close season for rod and line is 62 days i.e. 1st December to 31st January.

Bridging the Gap: While statutory protection is given to salmon, trout and freshwater fish (non-migratory trout and coarse fish) in England and Wales by the Salmon and Freshwater Fisheries Acts 1923 and 1975 (discussed below), in Scotland, Fisheries Acts before 1976 have extended no statutory protection to non-migratory trout and coarse fish. Because of the situation in England and Wales, fishing licence is required as well for non-migratory trout and coarse fish.

In Scotland the right to fish for salmon (including sea trout) is private which as a separate heritable estate can be and is often owned separately from the adjoining land. The waters and the rights to fish for non-migratory trout and coarse fish are private except in navigable estuaries and belong to the riperian owner who can lease out the right. It is obvious therefore that participation in angling which is very popular and said to be the largest participator-sport in Scotland depends on the willingness of the owner of the fishing rights to allow it.

Since the private waters are not statutorily protected, their owners can only take action under the Common Law to protect their waters and banks and not the fish therein. An unauthorised fishing for non-migratory trout is not a statutory offence. It is only an infringement of civil right.

Due to certain gaps in the Fisheries Acts and the scientific knowledge acquired about salmon and trout, there was the need for a review of the laws relating to salmon and trout fisheries in Scotland. The ~~second~~ Hunter Committee charged with this responsibility also reviewed the functions and powers of Fishery District Boards and recommended necessary changes.

The Committee report (Cmnd. 2691 H.M.S.O.) recommended that statutory protection should be extended to non-migratory trout and coarse fish. This should serve as an incentive to water owners to make improvements on the quality and quantity of brown trout fishings. Further the Committee recommended a compilation of a register of ownership of all fishings - salmon, trout and coarse fish for the purpose of statutory protection and easy administration. According to the Committee report, a Scottish Anglers Trust should be established. This Trust should register in its name and subsequently administer any fishings not registered by their owners.

The abolition of Salmon Fishery Districts with their Boards was recommended. In their place fourteen Area Boards were to be established. These Area Boards were to be expanded to cover brown trout and more fishing areas with a view of giving adequate protection and administration to freshwater fisheries.

Fishing licence for salmon, trout and freshwater fisheries in Scotland was recommended (Cmnd. 2691). Nearly all countries with rod fisheries of any importance require all anglers to hold a licence as it is in England and Wales. Scotland is unusual in having no rod licences. The purpose of licence is to provide means of identification and control, raise revenue and obtain statistics of anglers and their catches. Two categories of rod licence were suggested, one i.e. first class covering salmon, sea trout and brown trout fishing and the other i.e. second class, covering sea trout, brown trout and coarse fish.

Permit to fish in any particular water should be sought from the person having fishing rights over the water and the money paid belongs to the person with fishing rights. Revenue from fishing licence is for the upkeep of Area Boards, Scottish Anglers Trust and Fisheries in Scotland.

As for a net licence, a uniform fee of twenty-five pounds per net or catching device was recommended by the Committee. However the Area Boards would be empowered by byelaws to prescribe different fees to fit circumstances e.g. variations in net sizes and designs.

Sale of licences should be the responsibility of Area Boards and licences below the sum of two pounds could be sold by hotels, tackle dealers and appointed agents.

As for the Tweed which is a special area, a Tweed Area Board was proposed by the Committee for better protection to trout and freshwater fisheries in its Scottish and English areas.

<u>Freshwater and Salmon Fisheries (Scotland) Act 1976</u>: Following the need for better protection for freshwater fisheries and the Government acceptance of some of the second Hunter Committee 1965 proposals, which must have served more as a stimulant, the Freshwater and Salmon Fisheries (Scotland) Act 1976 was passed. This Act is aimed at increased availability of and protection for freshwater fishing in Scotland.

The Act stipulates that protection order can be made by the Secretary of State for Scotland in relation to an area of which proposals have been submitted to him and if he is satisfied that by the protection order there will be increased availability of fishing. By the protection order, persons without legal right or written permission from a person having such a right, are prohibited from fishing for or taking freshwater fish in the inland waters in the protected area.

The Secretary of State under this Act can only make protection order where he has received proposals in writing from or on behalf of an owner of land to which pertains a right of fishing; or an occupier of such right and where he (the Secretary of State) has consulted a body which in his opinion is representative of persons wishing to fish for freshwater fish in inland waters of Scotland. The Secretary of State may have regard to other circumstances in which fishing could be made more available in any waters other than those to which the proposals may relate, before making the protection order. Such circumstances may relate to permitted times of fishing, permitted maximum size of fish to be taken, maximum number of fish to be caught, permitted methods of fishing or tackle, amount of charges and permitted maximum number of rods allowed at one time.

A protection order can cease to be effective on a date specified therein but where no complaints concerning the implementation of proposals have been lodged, the Secretary of State may in his opinion after a review of the situation renew the protection order.

Wardens equivalent in functions to bailiffs, are appointed by the Secretary of State from among persons nominated to him by or on behalf of an owner of land to which a right of fishing for freshwater fish pertains. The wardens are to secure strict compliance with protection order.

By the 1976 Act, fish farmers in the U.K. are no longer guilty of contravention of certain enactments in the previous Salmon and Freshwater Fisheries Acts. Provisions are made enabling salmon farmers to harvest fish out of season, take ova, transport smolts, etc. In other words the 1976 Act gave recognition to fish farming, lifted the close season ban on farmed salmon and freshwater fish and exempted fish farms from all legislation relating to wild salmon with exception of the use of poisons and explosives.

<u>England and Wales:</u>

<u>Salmon and Freshwater Fisheries Acts 1923 and 1975</u>

By the Freshwater Fisheries Act 1878 the first statutory protection was given to freshwater fish. The Act authorised the setting up of Boards of Conservators for rivers that contained trout, char, and salmon. Before then, salmon and sea trout had long been protected by statutory Acts.

The Salmon and Freshwater Fisheries Act 1923, which conspicuously marked the beginning of extension of protection to freshwater fish including coarse fish, together with the Salmon and Freshwater Fisheries Act 1975 are meant to consolidate and amend the previous enactments relating to salmon and Freshwater Fisheries in England and Wales. These Acts have many similar clauses as those of the Scottish Fisheries Acts 1862 and 1868 for salmon and the Salmon and Freshwater Fisheries (Protection) (Scotland) Act 1951. The vital aspects only of the 1923 and 1975 Acts are treated below.

Mode of fishing: The 1923 and 1975 Acts prohibit certain modes of taking and destroying fish. They stipulate that no person shall use spear, light or any other forbidden instrument, throw or discharge any stone, sharp and injury inflicting object in any water for the prupose of taking, killing or facilitating the killing and taking of salmon, trout or freshwater fish.

The Acts, like other fisheries Acts, prohibit the uses of dynamite, explosive substances, poisons or noxious materials in any waters including any territorial waters adjoining the coast of England and Wales, with the intent to take or destroy fish.

Any malicious or wilful damage, breakdown of dams or sluice gates with intent to take or destroy fish is unlawful. The use, sale, purchase or being in possession of fish roe for salmon, trout or freshwater fish, fishing is strictly prohibited. Wilful disturbance to spawns, spawning fish and grounds, the killing of unclean or immature fish is forbidden.

The only known and permissible method of fishing within inland waters and estuary limit is by rod and line, net and coble. Fixed engines such as bag, stake and fly nets are allowed outside estuary limits on the seaward side and not in rivers.

A person may not be liable to a penalty in respect of any act done for the purposes of artificial propagation, or for scientific purpose, or for the purpose of preservation, or development of a private fishery provided he has obtained the previous permission in writing of the Fishery Board+ or Minister.

+ Fishery Boards (of England and Wales) mentioned in 1923 Act and in this context now refer to Water Authorities which are charged with fisheries responsibility since 1974.

Net mesh size: Taking or attempting to take salmon or migratory trout with any net of mesh size less than two inches in extension (when wet) from knot to knot, is prohibited. Mesh size less than two inches can only be permitted when used as a landing net during angling with rod and line.

Obstructions: Obstruction of passage of fish (salmon and migratory trout) with fixed engines is prohibited. Any engine used in contravention of this clause or for taking fish, is taken possession of or destroyed by any person acting under the authority of a Fishery Board or Minister. By the Salmon and Freshwater Fisheries Act 1923, the Fishery Board has the power to acquire obstructions or fisheries. It can purchase, take on lease any dam, fishing weir, mill dam, fixed engine or other artificial obstructions and any fishery attached to or worked in connection with such obstructions. The Fishery Board may alter, remove the obstruction or order for their removal in any lawful manner.

Fish pass: The 1923 and 1975 Acts stipulate that for any dam either newly built or reconstructed in any of the waters frequented by salmon and migratory trout, a fish pass must be incorporated and maintained in an efficient state. Failure to have a fish pass is an offence. Where it is not established, the Fishery Board or Minister may carry out any functions as to incorporate and maintain a fish pass and claim the cost of such a job from the owner or occupier of the dam or obstruction. Where a fish pass is improperly sited the Fishery Board with the consent of the Minister can alter it to avoid injury to fish stock.

Any wilful alteration or injury to fish pass or any act of obstruction to salmon and trout which in any way causes hindrance or prevention of fish from passing through a fish pass is an offence against the law. Water diversions for the purposes of mills or canals should have gratings across to prevent the descent of salmon or migratory trout, unless otherwise exempted by Minister or Fishery Board.

Times of Fishing: In a bid to ensure more protection to salmon, trout and freshwater fish, the Salmon and Freshwater Fisheries Acts have enforced fishing times and seasons. During the close seasons or times any person who fishes for, takes, kills or attempts to take or kill salmon with the gear for which the close seasons or times are made for, is guilty of an offence. For artificial propagation and other scientific purposes fishing can be done during the close seasons or times but with written permission of the Minister or authorities in charge of fisheries in the area. The Acts specify the minimum duration of close seasons and times for fishing as shown below.

		Minimum duration
Salmon	(Nets)	153 days
Salmon	(Rod and line)	92 days
Salmon or Trout	(Putts and putchers)	242 days
Salmon	Weekly close time	42 hrs.
Trout	(Nets)	181 days
Trout	(Rod and line)	153 days
Trout	Weekly close time	42 hrs.
Freshwater Fish OR Rainbow Trout - Close season		93 days

The authorities responsible for fisheries are empowered by Salmon and Freshwater Fisheries Acts 1923 and 1975 to make byelaws and fix for their respective areas, the annual close season and weekly close times for fishing, as may be expedient. The autonomy of the fishery authorities notwithstanding the byelaws made, should have annual close season for salmon between 31st August to 1st February while for rods between 31st October to 1st February. The annual close season (for salmon) for putts and putchers is between 31st August and 1st May while the weekly close time is between 6 a.m. Saturday to 6 a.m. the following Monday.

The annual close season for sea- trout is between 31st August to 1st March while for rod and line it is from 30th September to 1st March and the weekly close time is as for salmon.

Where byelaws have failed to specify close season for freshwater fish, the period between 14th March and 16th June should stand for the close season.

During the annual close seasons and times, no person shall buy, sell, expose or have in possession for sale any salmon or migratory trout. This however does not apply to individuals having in their possessions canned, frozen, cured, salted or dried salmon or trout from outside the United Kingdom or processed in the U.K. between 1st February - 31st August (the non-close season) of any year. Export of salmon or trout during the time at which sale is prohibited shall be entered with the proper officer of Customs & Excise before being sent to wharf or quay for shippment otherwise the goods can be confiscated.

An act by way of fishing, attempting to fish or non-removal of fixed engines, possessing salmon or trout through means not allowed by law during the close seasons and times is an offence against the Fisheries Acts 1923 and 1975.

Fishing Licence: Every Fishery Board or Water Authority is empowered to grant a licence for fishing. By issue of licence, they regulate fishing for salmon and trout and also freshwater fish in their areas. A person granted this licence is entitled to use an instrument specified in the licence in accordance to the provisions of Salmon and Freshwater Fisheries Acts to fish for any fish of a description in an area and for a period so specified. A fishing licence for the use of any instrument for fishing for salmon and trout also authorises the use of that instrument for freshwater fish and eels. Where exclusive right of fishing is involved, the person or association may be granted a general licence to fish in those waters. This may be subject to any conditions agreed between the authority and licencee. The number of fishing licences in any year can be limited. Applicants to whom licences are to be issued are to be selected where the number of licences to be granted is less than the number of applications.

The ten Water Authorities in England and Wales acting within the powers of Salmon and Freshwater Fisheries Acts 1923 and 1975, worked out the rates and charges for fishing licences (seasonal, weekly and daily) for their areas. A fishing licence from one Water Authority area does not allow for fishing in another Water Authority area. Table 14 below shows the charges for fishing licence for 1976 season for one of the Water Authorities in the U.K. - Welsh National Water Development Authority.

Table 14. Fishing Licence charges for W.N.W.D.A. - U.K. 1976

Salmon and Sea Trout

		A	B	C	D	E
Season Licence	Adult	£21.60	£18.0	£10.80	£7.20	£4.80
	Juv.	£10.80	£9.0	£5.40	£3.60	£2.40
Weekly Licence (169 hrs.)		£10.80	£9.0	£5.40	£3.60	£2.40
Day Permit		£3.60	£3.0	£1.80	£1.20	90p.

Key: A, B, C, D and E - refer to classes of waters (rivers) on the basis of the potential and general quality of the fishing. Best water - A and poorest water - E.

Juv. - Juvenile

Trout (non-migratory)

Season Licence	Adult	£3.0
	Juvenile	£1.50
Weekly Licence	Adult	£1.80
	Juvenile	£1.80
Day "	Adult	60p.
	Juvenile	60p.

Freshwater Fish & Eels

Season Licence	Adult	£1.80
	Juvenile	90p.
Day Permit	Adult	60p.
	Juvenile	60p.

It is an offence to fish or take fish or have in possession with an intent to use it, an instrument for taking fish without a valid fishing licence in any waters in which fishing of any description is regulated by a system of licensing.

4.3.2 RIVER POLLUTION CONTROL - LEGISLATION

In the United Kingdom the Water Act 1973 gave the English and Welsh regional water authorities broad multipurpose powers of water regulation and development. Among the functions of water authorities mentioned in Chapter 4.3.4, the authorities operate a comprehensive system for licensing water abstractions from surface and underground water sources and license and control discharges of wastes into streams. These water management activities permitted the English and Welsh water authorities are not provided for in Scottish Legislation.

In Scotland the functions of licensing and regulating water abstractions, pollution control, flood control, fisheries, land drainage, data collection and analyses are handled by a variety of organisations (statutory bodies). Water abstraction is regulated by the Secretary of State through water orders and consultation between Water Divisions of Regional Councils and Water Development Boards is required when new sources of water supply are to be investigated. But the Secretary of State could be furnished with information by the River Purification Board of any appreciable abstractions. Waste discharges are licensed by river purification boards in order to control pollution while development works for sewage and trade effluent treatments are carried out by local authorities, industries and private developers. The river purification boards of Scotland, like the water authorities of England and Wales, do not construct, operate or maintain waste treatment works.

The Scottish legal system is different to the English. In general fishery statutes passed by Parliament for England and Wales are not applicable to Scotland and normally separate Acts are passed for Scotland.

The early Salmon Fisheries Acts 1861 and 1868 for England and Scotland respectively partly dealt with river pollution control. Following the report of First Royal Commission on sewage in 1857, the River Pollution Prevention Act 1876 for the whole of the U.K. came into existence and empowered local authorities (e.g. town and county councils) to take civil proceedings against polluters.

The Salmon and Freshwater Fisheries Act 1923 also partly dealt with pollution and made it an offence for any person to pollute waters so as to make them harmful to fish or their eggs or food. The inland waters of the U.K. were further protected from industrial pollution by the Drainage of Trade Premises Act 1937 which allowed industries to discharge their effluents into sewers and the local authorities the responsibility of purifying them.

Rivers (Prevention of Pollution) Acts 1951: These Acts were simultaneously passed in England (for England and Wales) and Scotland and have the same basic principles but the statutory bodies responsible for their enforcement differ. The Acts repealed the River Pollution Prevention Act 1876.

Scotland: The Rivers (Prevention of Pollution) (Scotland) Act 1951 set up the River Purification Boards of Scotland. It conferred on them functions relating to the prevention of river pollution, to make provisions for the maintaining or restoring the cleanliness of the rivers and other inland and tidal waters of Scotland. The Act further conferred on the river purification boards the authority to conserve water resources where practicable.

Within the provisions of the Act, as it is for England and Wales, it is an offence to cause or permit entry of poison or poisonous or polluting matter into streams. It is an offence to impede flow of water in any manner in a stream which may lead to aggravation of pollution. The Act forbids any person from depositing on land matters that can be washed into streams and cause pollution. A person is guilty of an offence under this Act if he wilfully allows a substantial amount of vegetation cut or uprooted in a stream or so near to the stream that it falls into it.

The local river purification boards are empowered by this Act to make byelaws as may appear expedient to them for prescribing standards to determine when matter is to be treated as poisonous, noxious or pollutant. The byelaw can prohibit or regulate washing into streams anything like cloth, leather and wool that may cause pollution. It also regulates the siting and construction of outlets for discharge of effluents from any place used for sheep dipping.

A river purification authority has the right by the provisions of Rivers (Prevention of Pollution) (Scotland) Act 1951 to obtain and take away samples of water or effluent from streams where pollution has occurred or is suspected. Where entry into premises is required, there must be a twenty-four hours notice of entry given to the occupier of the land. The result of any analysis of a sample collected can be admitted as evidence in any legal proceedings against the offender. But the person taking the sample must notify the occupier of the land of his intention to have it analysed and shall there and then divide the sample into three parts, placed in different containers and sealed. He delivers one part to the occupier of the land, retains one and sends the other for analysis if he feels it is necessary.

The Rivers (Prevention of Pollution) (Scotland) Act 1965 made further provision for maintaining or restoring the cleanliness of the rivers other inland and tidal waters of Scotland. It extended the control power of the river purification boards to cover existing discharges to rivers and new discharges to certain areas of tidal waters.

It stipulates that any discharge of effluents apart from the ones specified in the 1951 Act should be done with the permission of river purification boards. Such written applications for permission should state nature and composition of effluent and its maximum temperature at time of discharge. It should also state highest rate of discharge proposed and the maximum volume to be discharged on any one day.

Approval for discharges is subject to the conditions laid down by the river purification boards. These conditions are the most clearly established and discreet tool available for implementing improvement programmes within the Scottish water pollution control arrangements. Consent of the river purification boards provides the goals to be achieved by dischargers and is a yardstick for measuring deviation from the established objectives. Even though dischargers have to comply with the provisions of the 1951 Acts, permission or consent for any discharge is at times subject to such conditions river purification boards individually may prescribe.

The Royal Commission on Sewage Disposal, Eighth Report, recommended that wastes should not contain solids in suspension of more than 30 mg/l and that the Biochemical Oxygen Demand (B.O.D.) in

5 days should not exceed 20 mg/l i.e. 30:20 standard as it is called. Although the river inspectors of river purification board use the Royal Commission standard for the quality of sewage effluent before permission is granted for discharge, they are not bound by the Commissions recommendation (Hubbard, 1968). The river inspectors believe that empirical knowledge is better relied on than a set standard particularly for industrial discharge. The river purification boards usually set out their standard which depends on the quality of the discharge, the volume and the uses of the recipient water.

With respect to industrial discharges, the standards vary with the situation but generally an upper limit of 60 p.p.m. suspended solids, a pH between 5 and 9 and substantially no trace of oil or grease are required (Hubbard, 1968). Where the inland water is subjected to many uses; agriculture, domestic supply, fisheries, navigation etc. more stringent limits may be applied on the quality of effluents to be discharged into it.

England and Wales: The Rivers (Prevention of Pollution) Act 1951 for England and Wales has basically the same principles as that of Scotland.

The easily identifiable difference between England and Wales and Scotland is in the legal bodies responsible for the enforcement of the 1951 Acts. The regional water authorities are responsible in England and Wales but in Scotland the local river purification boards (since regionalisation they are often referred to as river boards).

4.3.3 HYDROELECTRIC DEVELOPMENT (SCOTLAND) ACT 1943

This Act is only applicable to Scotland where some salmon rivers are affected by hydroelectric dams. The Act makes it a duty of the North of Scotland Hydroelectric Board to avoid in any possible way injury to fisheries and to fish population in any waters affected by hydroelectric dams.

By this Act the Secretary of State for Scotland appointed a Fisheries Committee to advise and assist the Electric Boards. Before any hydroelectric dam is constructed the Committee (made up of fisheries, administration, water and electrical engineering experts) is consulted by the Electric Board for its recommendation. The implementation of any disputed recommendation or suggestions rests with the Secretary of State.

In the bid to avoid injury to fisheries and stock of fish as demanded by the Act, efforts are made in any way possible, to supplement stock and allow salmon runs to their spawning grounds. It is obligatory for the North of Scotland Hydroelectric Board to establish fish passes (ladder) or fish lifts to allow passage of salmon through the dams during their migration to the spawning sites. Stock supplementation is usually worked out by the establishment of a trapping system below the dam, stripping and hatching the eggs in the hatcheries usually incorporated in the dam as at Pitlochry. Although the hatcheries are built by the Hydroelectric Board, they belong to and are worked by the Fishery Boards whose waters are affected.

In England and Wales most rivers are not affected by hydroelectric schemes as in Scotland and, where they are they might not necessarily be important salmon rivers.

4.3.4 <u>WATER ACTS 1963 AND 1973</u>

These Acts are meant for conservation of water which is important not only in fisheries management but in everyday life - domestic and industrial. The Acts only apply to England and Wales.

By these Acts the Sécretary of State and Minister of Agriculture, Fisheries & Food are charged with the duty of securing effective execution of policies relating to conservation, augmentation, distribution and proper use of water resources. They too have to look into other aspects of land drainage, fisheries in inland and coastal waters, use of water for navigation and recreation, sewerage and treatment, disposal of sewage and other effluents, restoration and maintenance of wholesomeness of rivers and other inland waters.

The Water Act 1973 established the former River Authorities in England and Wales as Water Authorities with the additional functions of water conservation and land drainage. It authorised the Water Authorities to issue licences for water abstraction, to make surveys of their area, gauge and keep records of flow or volume and other characteristics of any stream in their area. The Act stipulates that in working out the minimum acceptable flow - M.A.F. for the water from which abstraction is to take place, the Water Authorities should have consideration for other public interests - health, navigation, recreation etc. - land drainage, agriculture, industry and domestic water uses.

Scotland is not affected by the Water Acts. The River Purification Boards of Scotland derive some of their power of water conservation from the Spray Irrigation (Scotland) Act 1964.

4.3.5 MISCELLANEOUS ACTS

DISEASE OF FISH ACT 1937

This Act enables the Ministry of Agriculture and Fisheries, Water Authorities in England and Wales, Secretary of State for Scotland and Scottish District Salmon Fishery Boards to take measures to check the spread of diseases among fish in the United Kingdom.

The Disease of Fish Act 1937 strictly prohibits the importation of any live fish of the salmonid family into the United Kingdom unless such an importation or introduction has been permitted by the Minister for Agriculture, Fisheries and Food or by the Secretary of State. Such an importation should be cleared free of disease and health certificate issued before being allowed into the United Kingdom.

However the same Act stipulates that live freshwater fish, their eggs and the eggs of fish of the salmonid family may only be imported under a licence issued by the Minister for Agriculture, Fisheries and Food or by the Secretary of State. A licence may be refused if the Secretary of State or Minister apprehends that the proposed importation may lead to an outbreak or spread of disease.

The Minister has special powers by this Act to prevent the spread of disease from any waters infected with furunculosis or any fish disease by applying the clauses of this Act and declaring the area to be an infected area. By doing so, the movement of fish stock from such waters is prohibited and protection from infection is thereby given to other waters and stock of fish.

In a review of Disease of Fish Act 1937 the Hunter Committee report (Cmnd. 2096 H.M.S.O.) suggested more protection from disease for fish stock. By this the Committee recommended that Water Authorities, Fishery Boards should be empowered to regulate by byelaws the introduction of live fish into any waters in their area. This procedure is to avoid stocking of undesirable or diseased fish species in the waters.

In recent years a number of additional diseases have been included in the Act. These are IPN, IHN, VHS, Whirling disease and columnaris.

SPRAY IRRIGATION (SCOTLAND) ACT 1964

This Act enables the river purification boards of Scotland to control water abstraction for the purposes of spray irrigation. By applying this power the local river purification boards are to control the amount of water abstracted by farmers for irrigation, conserve water and thereby prevent drought situations in places where rainfall is poor. The purification boards check out for water abstraction and furnish the Secretary of State for Scotland of illegal substantial abstraction of water.

The Spray Irrigation (Scotland) Act 1964 has further empowered river purification boards to make surveys of their area, gauge and keep records of flow or volume and other characteristics of any stream in their area.

The Water Divisions of the Regional Councils control the water in the reservoir for domestic supply in Scotland and the local river purification board may help to decide on the level of compensation flow from reservoirs to the streams. The Fishery Boards are also consulted before there are abstractions in order not to jeopardise the fisheries in the donor river.

Chapter 5

ADMINISTRATIVE AND MANAGEMENT MACHINERY

As the uses of water increase and sources of pollution grow, so too, the legal provisions and authorities must expand to keep pace. Previously most provisions for fisheries administration, control of water uses and pollution were reflected in the local codes and laws. This resulted in the creation of diverse bodies to administer this legislation. The administration was not uniform since local interests were only catered for. The result was a conflict of interests in water uses and the ultimate failure to achieve the required water quality standards. This situation led to further deterioration of the waters administered.

It then became necessary to establish the present administration and more centralised authorities whose objective is to coordinate different arms of the legislation, for effective management of fisheries, water resources and control of pollution. Secondly the objective of the administration is to generate systems of control to allow for reconciliation of various interests on the basis of sound technical and scientific knowledge, by projecting plans and considerations for the maintenance of water resources in a condition suitable for different users.

Administrative bodies vary from place to place. In Scotland the District Fishery Boards are responsible for the protection of migratory fish stocks. The River Purification Boards are responsible for the prevention and control of river pollution and water conservation through control of water abstraction for irrigation while the Water Divisions of Regional Councils undertake water supplies and development and control abstraction through licensing. The Scottish Development Department, which is a central government unit, advises the Secretary of State on local matters, executed by all local bodies under her e.g. local authorities, local purification boards etc.

In England and Wales the Regional Water Authorities are responsible for fisheries administration, water resources, water pollution, land drainage and water based amenity and recreation. The National Water Council coordinates the activities of the water authorities and acts in an advisory capacity on matters concerning national policy for water. The Water Space Amenity Commission also, jointly with the water authorities, is concerned with water-based amenity and recreation.

5.1 DISTRICT FISHERY BOARDS

A body of commissioners appointed by the Salmon Fisheries (Scotland) Act 1862 to fix boundaries of fishery districts and define estuary limits, set up the District Fishery Boards for Scotland.

The responsibilities of the boards for the improvement and protection of salmon fisheries in their districts have already been discussed under the Salmon Fisheries Acts 1862 and 1868 (Chapter 4.3.1.). The memberships of these boards are entirely of proprietors holding rights of salmon fishing.

The Fishery Boards can appoint water bailiffs as the regional water authorities and alter or instal a fish pass where necessary.

Where salmon rivers are affected by hydroelectric dams, the fishery boards in cooperation with the North of Scotland Hydro-electric Board (discussed below) carry out measures to protect and maintain salmon stocks in these rivers. In pursuit of this objective fish movement i.e. salmon and grilse run to and from spawning grounds through the dams may be recorded which helps to ensure that an adequate run is still maintained through the fish pass in the dam and where runs are lower than usual, because of improper siting of the fish pass or for some other reasons, measures could be taken to improve the situation.

Counts of salmon and grilse movement through the dam are kept by the North of Scotland Hydroelectric Board and made available to the fishery boards. The counts are taken with the aid of an electronic counter installed in the fish pass. In the Conon District the number of salmon and grilse passing through the Torr Achility, Meig and Luichart Dams has been recorded since 1956.

At Pitlochry in the Tay District, the Fishery Board also receives a record of the number of salmon and grilse moving through the dam. In the Awe District, at Inverawe barrage fish movement is also recorded. Other districts e.g. Ness and Shin also record fish movement through the dams. This process is one of the potential ways of looking into fisheries condition because of the obstruction caused by the dam.

Salmon trapping and stripping are carried out by fishery boards for artificial propagation. The 'eyed' ova are planted out or incubated in their hatcheries and the fry planted out. The activities of fishery boards in connection with artificial propagation have been discussed in Chapter 4.1.2.

Redd counts are also made by fishery boards to determine any changes in spawning activities of salmon and trout. However this aspect of estimating the progress in improvement measures is not very reliable for water conditions may make redd counting difficult. But in 1965 the Spey District Fishery Board recorded 67 redds above the Truim Dam (North of Scotland Hydroelectric Board Ann. Report, 1966). The North Esk Fishery Board also recorded 2594 redds in 1971, 2516 in 1972, 2402 in 1973, about 1200 in 1974 and 2720 in 1975 (North Esk Fishery Board Ann. Report, 1976).

Although the fishery boards have limited powers in relation to salmon fishing, they had no real powers or functions in relation to brown trout and freshwater fisheries. But with the Freshwater and Salmon Fisheries (Scotland) Act 1976, statutory protection is extended to brown trout and freshwater fish. Fishery Boards do not issue fishing licence since no rod licences are required in Scotland.

Following the review of the Fisheries Acts by the Hunter Committee and to bridge the gap in the functions of the District Fishery Boards, the Hunter Committee (Cmnd. 2691) recommended that the fishery boards should be replaced by Area Boards with wider functions. Fourteen Area Boards, 1. Ayrshire, 2. Clyde, 3. East of Scotland, 4. Forth, 5. Highland, 6. Moray Firth, 7. Northern, 8. North East Scotland, 9. Orkney and Shetland, 10. Ross and Cromarty, 11. Solway, 12. Tay, 13. Tweed and 14. Western Isles, which will be fewer in number and cover wider areas than the former boards, were recommended. They are planned to represent fishery interest at large, have management functions and a considerable number of regulatory powers to complement the powers of the Secretary of State.

The Area Boards will, if ever established, control methods of fishing, levy fishery rates and issue proposed rod and net licences. They would also exercise the functions relating to brown trout and coarse fisheries in addition to salmon fisheries.

With the passing of the new Act - Freshwater and Salmon Fisheries (Scotland) Act 1976, based considerably on recommendations of Hunter Committee (Cmnd. 2691), Area Boards were not formed and licence for rod fishing was not covered. But protection to freshwater fish could be given on application for a protection order by one having a right of fishing in the area or on behalf of one having such a right. The Secretary of State in granting such a protection order, only does so if he is satisfied that there will be increased availability of fishing.

5.2 RIVER PURIFICATION BOARDS

The River Purification Boards of Scotland which are under the Scottish Development Department are clearly the basic governmental unit about which pollution control programmes revolve. They are not directly concerned with fisheries as the water authorities of England and Wales and the Fishery Boards of Scotland.

The river purification boards were established by the Rivers (Prevention of Pollution) (Scotland) Act 1951. They are conferred, by the 1951 Act, with the functions of controlling and preventing water pollution and promoting the cleanliness of tidal and inland waters. For the purposes of enabling them to perform these functions, a river purification board may make surveys of its area, gauge and keep records of the flow or volume and other characteristics of any stream in its area. In promoting the cleanliness of water, the board takes note and informs the Secretary of State for Scotland of any effluent discharge, the type, the water into which such a discharge is made and by whom.

The boards are also bestowed with the duty of conserving water resources where practicable. In doing this, they take note of water abstraction, record the volume of water removed from any streams by industries and agriculture for spray irrigation (Reference Spray Irrigation (Scotland) Act 1964), while the Water Division of Regional Councils are concerned with water supply for both domestic, industrial and other public uses and augmentation proposals for places where water shortages occur.

There are at present eight river purification boards - Clyde, Forth, Grampian, Highland, Northeast, Solway, Tay and Tweed in Scotland. These local river purification boards can make byelaws within the ambits of Rivers (Prevention of Pollution) (Scotland) Act 1951 as may appear expedient to them.

The boards have done much to improve the qualities of the rivers where pollution has occurred and maintain the qualities of clean water. This effort has greatly reflected on the general well being of the fish stock in some Scottish waters. For example the River Tweed is still maintaining its water quality and retaining its position as the most salmon supporting river in the U.K. due to the efforts of the Tweed River Purification Board. River Don in Scotland known to have been affected by loads of industrial and domestic pollution is greatly improved due to the effective operation of the North East River Purification Board and the setting up and operation of Persley Sewage Treatment Works by the local authority (Scottish River Purification Advisory Committee Report 1973).

The Scottish River Purification Advisory Committee is an official body established by 1951 Act to advise the Secretary of State,

> "...... on any matters relating to the cleanliness of the rivers and other inland waters and the tidal waters of Scotland and to the prevention of pollution of such rivers and waters and of considering the enactments relating to the prevention of the pollution of such rivers and waters and of making to the Secretary of State such representations as the Committee thinks desirable concerning the matters aforesaid".

Members of this Committee appointed by the Secretary of State are individuals with vested interest in pollution prevention and control. They could be from river purification boards, Anglers Cooperative Association, industries and manufacturing companies. The Committee relies on its membership to obtain information on pollution matters and on staff work of the Scottish Development Department (to be treated later).

By the 1968 Sewerage Act, the river purification boards are empowered to deal with sewage disposal in Scotland. There are about 234 local sewerage Authorities in Scotland. These and the local river purification boards work jointly. The sewage treatment works comply with the standards - 20 mg/l B.O.D. and 30 mg/l suspended solids laid down by the Eighth Report of the Royal Commission on Sewage.

For effective control of pollution a large diversity of disciplines are required, including administration, biology, chemistry, hydrology and Inspectorate. Each board is headed by a river inspector who may be called director or chief technical officer.

All chemical and biological tests to determine water quality are done by chemistry and biology sections respectively. By use of biotic index the biology section is able to establish the presence of pollution either by abundance, absence or irregular distribution of particular species of invertebrate fauna. Biotic index is a biological measure used in determining water quality. It involves biological grouping of invertebrate fauna according to their affinity to different levels of pollution. Biotic Index (B.I.) has a value 1-10 and the form which it will take in classification is determined by the nature of the work of the biologist concerned. Thus the scheme drawn up for one area may not necessarily serve for another place. However for simplicity, values below 4 usually indicate badly polluted water condition with no fish but tubificid worms and/or red chironomids larva and *Asellus* sp. being abundant. Values between 5 and 7 indicate moderately polluted condition with some fish and presence of invertebrates, like *Gammarus* sp., some molluscs and fly larvae e.g. *Tricoptera* (caddis fly). Values above 8 show little or no trace of organic pollution with abundance of fish and invertebrate fauna like *Ephemeroptera* (May fly) and *Plecoptera* (stone fly).

Water quality is also determined and classified on chemical criteria by the Chemistry section as shown in Table 5, Chapter 3.1. The criteria set up by the river purification boards for grossly polluted rivers include; incapability of supporting fish life, complete deoxygenation, offensive odour and appearance, high B.O.D., absence of macroscopic invertebrate fauna and presence of highly tolerant organisms to pollution.

The Inspectorate section has district inspectors who carry out routine inspection and sampling of sewage and trade effluents in the board's area of operation. The district inspectors are in continuous contact with people in the field. They collect samples of discharges, discuss problems with dischargers and review applications for consent. The conditions attached to consent are essentially the product of a river inspector. For granting of consent, a river inspector uses methods best described as individualistic (Hubbard, 1968). These methods include - Royal Commission standard, empirical knowledge, assessment of levels politically and economically obtainable and an expectation that higher standards are possible in the future.

The Inspectorate section investigates complaints of pollution, carries out surveys, samples estuaries and inter-tidal zones, rivers and tributaries for pollution detection and prevention. Above all it investigates fish mortalities, consults with industries, local authorities and public works undertaking in connection with waste treatments and disposals. Administratively it is coordinating and advisory in function particularly in all aspects of pollution prevention.

5.3 SCOTTISH DEVELOPMENT DEPARTMENT

Scottish Development Department is a central government unit concerned with matters pertaining to local government of which sewage treatment, water supply and roads are examples. It is concerned with pollution control through its responsibility to the Secretary of State and acts as his administrative arm to ensure that Pollution Acts are carried out. The Scottish Development Department, however, does not have a direct responsibility towards all these programmes mentioned. Rather it has an advisory, information dispersal, review and approval function for plans developed and carried out by local authorities. Although the Department may have a significant influence in the conduct of local activities by approval of plans for development schemes, loans for constructions and other advisory functions to the Secretary of State on local matters of importance, it has no specific regulatory powers.

The technical branch (i.e. engineer inspectors) of the Department provide further assistance and advice to the local authorities in addition to that given by river inspectors of local river purification boards. In return they receive information on the working condition of local authorities and problems in the local areas. The information gathered by the Scottish Development Department through committees, associations, boards and informal contacts comes to a climax in the preparation of legislation which usually takes the form of a government bill. Scottish Acts on local matters have come through this process.

5.4 REGIONAL WATER AUTHORITIES (ENGLAND AND WALES)

The present water authorities originated from River Boards. River Boards were formed by the River Board Act 1948 in accordance with the recommendation of the Central Advisory Water Committee in 1937.

By Water Resources Act 1963, the River Boards became known as River Authorities. Through the reorganisation which followed the Water Act 1973, the River Authorities became Regional Water Authorities. The ten regional water authorities are: Anglian, Northumbrian, North West, Severn-Trent, South West, Southern, Thames, Wessex, Wales and Yorkshire. These authorities are responsible for fisheries, water pollution control, water conservation, inland drainage and other functions related to water in England and Wales.

Fisheries: The water authorities are responsible for salmon, trout and freshwater fisheries in their areas. They are to maintain, improve and develop the salmon, trout, freshwater and eel fisheries in their areas for which they exercise the functions under the Salmon and Freshwater Fisheries Acts 1923 and 1975. For effective discharge of their functions the water authorities can establish an advisory committee of individuals interested in fisheries.

As part of their responsibility, the water authorities maintain hatcheries to supplement natural stocks of fish, operate fish farms, issue rod fishing licences, collect data on catch and angling pressure, open up new fishing grounds to ease angling pressure and distribute amenity, make regulations and byelaws within the powers of Salmon and Freshwater Fisheries Acts to protect fisheries in their areas. They carry out fish rescue operations when fish stocks are threatened with extermination by natural and artificial hazards, assess fish stocks in their waters where production is considered low and are involved in research work towards production of better qualities of fish that can achieve fast growth and produce enough brood stock to meet demand.

In addition the water authorities protect the interests of anglers by investigating their complaints, stocking and maintaining reservoirs, canals and streams with species of fish required by anglers.

All the reservoirs and some natural lakes in Wales are under the control of Fisheries staff of Welsh National Water Development Authority (W.N.W.D.A.). It is the declared policy of this authority to develop and manage their fisheries so as to provide more and better sport for the maximum number of people.

In England, except for a few reservoirs, most reservoirs are under the control of the water authorities who have exclusive authority over their fisheries and other functions connected with water.

In addition to fisheries functions the water authorities liaise with Nature Conservancy Council in the conservation of nature, including the flora and fauna, and other physiogeographical features of special interest either in rural or urban areas.

The source of revenue for fishery expenditure is mostly from local tax and licence duties. See reverse of page.

In order to carry out Fisheries duties and conservation functions, the finances required by the Regional Water Authorities of England and Wales are obtained from three main sources.

a) Direct levy on rateable properties. By this an owner of rateable properties pays a certain amount of money each year to the Water Authority in his area. The amount paid could depend on the levy rate or on the value of his properties rated.

   i) Sewerage charges:- This is the money derived by Water Authorities from owners of properties connected to main sewers. The owners of such properties, especially industries, pay for the service (i.e. the treatment of waste discharges) rendered by the local sewerage works.

   ii) Environmental service charge is levied on owners of properties not connected to main sewers.

b) Because of the recreation offered by inland fisheries, anglers have to obtain fishing licences and permits. The revenue from these, and that collected from owners of fisheries, are used for the maintenance of fisheries in the area.

c) Each financial year, the government, through the Ministry of Agriculture, Fisheries and Food gives a grant to each Water Authority for the upkeep of its functions.

In Nigeria, the finance for the maintenance of the State and National Inland Fisheries is mainly from the government. In the annual budget of each State Government, financial allocation is made through the appropriate Ministry to Fisheries. Also, the Federal Government which is the central authority gives a grant to each State Fisheries through the Federal Fisheries. Help from foreign governments is usually in the form of technical assistance and is channelled through the Federal government. The Federal and State financial allocations to Fisheries are for the establishment and development of Fisheries in the country. Such projects are the responsibilities of the ministries concerned.

Privately owned fisheries are privately maintained either by families or cooperatives. The revenues from these belong to the owners.

Property and other rates locally levied on taxable adults are collected and spent by local government authorities on local public utilities, sanitation and recreational parks of which fisheries are distincly absent.

In this instance it would be an unsound policy to use part of the rate payer's money to maintain an establishment from which the rate payers would not benefit. Similarly government investment of the proportion of their finances on small private inland waters and fisheries where financial returns or any form of accountability might not be rendered, would not be worthwhile. Even though technical advice is given private fisheries by the government through the ministries, government expenditure on private fisheries would be justified if the government would exercise control on

Water Bailiffs: For the exercise of fisheries functions, water bailiffs are employed by water authorities. These bailiffs, like water inspectors, have the same powers, privileges and liabilities. They watch out for illegal fishing. They have powers to search suspected poachers, inspect fishing licences and confiscate the tackle of anglers in suspicious circumstances. They are empowered to seize illegally caught fish and equipment used and can take legal proceedings for an offence committed by a person infringing the Salmon and Freshwater Fisheries Acts.

Water Pollution Control: The Central Advisory Water Committee under the Secretary of State is chiefly a body charged to serve and co-ordinate the activities of water authorities. To this end, her policies and efforts and those of water authorities with due regard to their responsibilities are oriented towards better resource management and cleaner water. Because water authorities have multiple functions, their membership has called for representatives from various fields - industry, fisheries, agriculture, public water supply and also members from local councils. The inclusion of local council members is essential because of their role in local government (Reference Drainage of Trade Premises Act 1937, Chapter 4.3.2). The local authority sewerages have power to the limit and quality of their effluent intake from industries, particularly where the effluent has not undergone initial treatment and is suspected of having a high biochemical oxygen demand or toxic effect.

By the 1951 Act i.e. the Rivers (Prevention of Pollution) Act 1951, the water authorities are authorised to license dischargers, give or refuse consent to applications for discharge and test effluents to ensure that they comply with the required standards before their discharge. In effect, for the purposes of controlling and preventing water pollution and promoting the cleanliness of tidal and inland waters of England and Wales, the water authorities discharge their duties just the same way as the local river purification boards of Scotland. Water quality is also determined through the biotic index and chemical criteria by the biology and chemistry sections respectively.

Water authorities rely on their field staff of water inspectors for information. They, as water constables, have their privileges and liabilities. Water inspectors are given powers of entry into premises for effluent sampling where pollution is suspected or has occurred. Effluent samples collected are analysed to ensure that they conform to the Royal Commission 20/30 standard. In case of legal proceedings against polluters, the result of the analysed samples are tendered in court, as evidence.

The financial support of these local authority sewerages through which the water authorities operate comes from the central authority. Charges are also imposed on industries responsible for these effluents. It has been estimated that about 70% of all industrial effluents in the United Kingdom pass through public sewerage systems.

<u>Water Conservation</u>: By the Water Act 1973, the water authorities are empowered to supply water within their area, authorise the supply of water by statutory water companies on behalf of water authorities and make provision for sewerage and sewage disposal facilities for draining effectively their areas. They are to redistribute, conserve and augment water resources e.g. by treatment of salt water by any process for removal of salt or other impurities.

On abstraction, the regional water authorities are to issue licences for water abstraction, make surveys of their area and carry out those functions necessary for water conservation as enshrined in the Water Act 1973 (Chapter 4.3.4).

The complex nature of the responsibilities of the regional water authorities has called for the establishment of diversified disciplines since their effective operation depends on a combination of skill, knowledge and experience. It is not easy to mention the efforts of all the sections of water authorities since their activities are intertwined. In passing, therefore, brief comments on biology and chemistry sections might suffice.

The biology and chemistry sections are more science and research oriented. The biology section carries out invertebrate fauna surveys, determines the quality of water through a standard biotic index, looks into fish food available and diseases and works very closely with the fisheries section.

The chemistry section is concerned with chemical analysis of the water to determine its quality and detect elements responsible for pollution in bodies of water where pollution has occurred.

5.5 OTHER BODIES

NORTH OF SCOTLAND HYDROELECTRIC BOARD

By the Hydroelectric Development (Scotland) Act 1943, the North of Scotland Hydroelectric Board "shall have regard to the desirability of avoiding as far as possible injury to fisheries and the stock of fish in any waters affected by hydroelectric schemes". For any proposed scheme, the North of Scotland Hydroelectric Board has to fulfil this statutory obligation as demanded by the 1943 Act to alleviate problems on fisheries created by hydroelectric dams. A fish pass where it is desired should be installed to allow for the passage of migratory fish through the dam. Where needed, traps as at Loch Poulary and Loch na Croic on the River Garry and on the River Blackwater respectively could be installed for taking of adult salmon for their eggs. Provision is also made for hatcheries, as at Pitlochry, Invergarry and Inverawe schemes, in which the fertilised eggs can be incubated.

The provision of a regulated flow, that is, compensation flow, below the board's schemes to enable as appropriate adult salmon and sea trout to ascend the rivers and spawn, the eggs of fish downstream to develop and the young fish to feed and grow in suitable condition is a necessary corollary.

In order to obtain some reliable counts of fish ascending and descending the passes, the Board has to instal an electronic counter. This consists of a tubular lining with three built in electrodes for fitting into an orifice through which the fish have to pass. The passage of fish through the tube causes a disturbance in the electric field maintained in the electrode and this is transmitted through electronic circuits to be recorded on a meter. The counter distinguishes between direction of passage and size of fish. Smolts are not counted by this device.

The North of Scotland Hydroelectric Board used to undertake some research projects in connection with passage of smolts and kelts through fish passes in cooperation with Salmon Research Committee which is now disbanded. All these measures carried out by the Board are to ensure adequate passage of salmon across the dam and avoid possible injury to fisheries and stock of fish either below or above the dam.

NATIONAL WATER COUNCIL

This council was established by the Water Act 1973 and it only operates for England and Wales.

About half the members are from Water Authorities. These are already acquainted with the problems existing in water conservation and fisheries administration.

The council functions only on an advisory capacity on matters concerning national policy for water and other matters of common interest to regional water authorities. As a co-ordinating power it helps to prepare a scheme for training and education in connection with the services provided by regional water authorities. By its administration the council promotes the efficient performance of the functions of water authorities in research fields particularly.

WATER SPACE AMENITY COMMISSION

The Water Act of 1973 established the Water Space Amenity Commission (WSAC). Its heterogeneous members are drawn from the countryside commission, English Tourist Board, Sports Council, and other bodies or local authorities interested in water for recreation e.g. angling, yachting, sailing etc. All chairmen of water authorities are members and the Chairman of the Water Space Amenity Commission is drawn from the National Water Council (NWC).

This Commission is all embracing in water recreation. It also protects and conserves fisheries for sports and recreation. In the exercise of its functions, it advises the Secretary of State on formulation, promotion and execution of national policy on water for recreation and amenity in England. It also assists regional water authorities in preparing plans and programmes for fisheries and water management, survey, quality studies for present and future use and prepares plans to meet future water demand. It has an advisory link with National Water Council as well. In the exercise of these functions every interest in water use is protected and thereby avoids unnecessary conflicts.

Chapter 6

NIGERIAN FIELD

Nigeria has considerable marine and freshwater fisheries resources. She has a coastline of over 800 km, extensive brackish water lagoons and creeks, rivers, lakes (Chad & Kainji). These water systems and the eutrophic lakes if harnessed wisely would be a landmark in resource development and fish production.

The main source of water to Lake Chad is the River Chari which empties about 33 cubic kilometers per year (Fry, 1971). The lake further receives on its surface about 300 mm of rain per year. Much of the water lost from the lake seeps westwards through the River Yobe to drain through Logone marshes into River Benue. Owing to climatic changes the size of the Lake Chad has been fairly difficult to estimate. Fry (1971) accorded it 26,000 sq. kilometers based on early surveys of the lake. About 2 million tons of solute are released into the southern part of the lake yearly from the River Chari. Due to this huge inpouring of nutrients and their circulation in shallow water by strong winds which blow throughout the year, the warm waters of the lake are remarkably productive.

The absence of rocks, rapids and great depths and the presence of organic matters have contributed to the richness of Lake Chad and the abundance of some species of fish. About 86 species of fish abound. The most important fishery in the lake is Lates niloticus which is landed almost all the year round (F.A.O. 1967). Among the abundant species are: Heterotis niloticus, Alestes spp., Hydrocyon forskalii, the snout fish, Gymnarchus niloticus, Mormyrus rume; the Bagrids - Bagrus dogmac, B. bayad, the mudfish - Clarias spp., Heterobranchus spp. and other members of catfish e.g. Synodontis spp. and Chrysichthys spp. The cichlids - Tilapia spp. and related genera like shallow and shaded inshore waters and so not commonly found in the open waters of the Chad. In one fishing season - August to April about 300 metric tons of Lates sp were caught by gill net in Lake Chad (Tobor, 1973).

The total fish supply to Nigeria from all sources is about 800,000 metric tons per annum (Federal Department of Fisheries, 1973). Of this quantity about 640,000 metric tons are produced while 160,000 metric tons are imported.

Fish demand in Nigeria is about one million metric tons every year. With the present rate of population growth and the rise in income levels, it is estimated that the effective demand for fish will exceed 1.5 million metric tons by 1980 (Federal Department of Fisheries, 1973). To catch up with this demand the pace of fisheries development in Nigeria is guided by fisheries policy which is pursued at two levels - Industrial and small-scale+ fisheries locally carried out.

The industrial level is mainly marine involving inshore and offshore trawling. The 'artisanal' level is mostly fresh and brackish water fisheries which are generally characterised by low productivity and intensive labour. Table 15 gives a breakdown of the quantity of fish produced by the industrial and 'artisanal'

+ Small-scale fisheries are labour-intensive and are locally conducted by artisanal craftsmen whose level of income, mechanical sophistication, quantity of production, fishing range, political influence, market outlets, employment and social mobility and financial dependence keep them subservient to the economic decisions and operating constraints placed upon them by those who buy their production. This second level of production generally referred to as 'Artisanal level' in Nigeria, has been so referred to in this chapter.

fisheries out of about 640,000 metric tons of fish produced yearly in Nigeria.

In the pursuit of the 'artisanal' level of fisheries development, Nigeria is trying to diversify development in order to meet up with future exploitation. Just as some countries like the U.K., are conscious of the consequences of exploitation of their fisheries if sound conservation and management principles are not applied, so too Nigeria is conscious of possible effects of inadequate development to meet future needs.

The establishment of National Accelerated Fish Production Project (N.A.F.P.P.) in Nigeria is a positive step towards fisheries development. The essence is to bring the benefits of modern technology to many Nigerian fishermen currently involved with artisanal fisheries. Worthy river crafts, outboard engines, modern fishing gear, government assistance (credit facilities) are provided to fishermen cooperatives. Active propagation of better methods of preserving and marketing fish are introduced to them. Proper processing and storage of fish will help to prevent unnecessary economic loss. This will improve the low productivity of artisanal fisheries and the status of the fishermen community who are reduced to the backward class in socio-economic standing because of the poor yield generated by their traditional and unscientific approach to fisheries.

There is also the scope to develop small reservoir fisheries. Vast area of water to be created from the numerous irrigation dams and canals for crop production are proposed to be used for fish seed production. These dams and canals are estimated to be several thousand hectares. The Tiga Dam project alone in Northern Nigeria is expected to provide 20,000 hectares of water reservoir

Table 15. Fish Production Statistics for Industrial and Artisanal Fisheries in Nigeria for 1972 and 1974.

Source .... Federal Department of Fisheries, Lagos 1973

Type of Fishery	Method	Fish Production in metric tons 1972	1974
<u>Industrial</u>	Trawlers	5,000	77,400
+ <u>'Artisanal'</u>			
(1) Coastal & Brackish water (Creeks & Lagoons)	small, large paddled and motorised canoes operating from remote and scattered villages. Use beach seines, traps hooks & nets (set, cast & drift)	396,000	404,000
(2) Freshwater (Rivers & Ponds)	"	164,500	167,500
(3) Lakes (Chad & Kainji)	Motorised canoes at times but mostly paddled canoes. Use of nets & traps of assorted kinds	78,000	60,000
(4) Fish farms	Yet to be of significant consequence in fish production. Production figures not easily obtained.		

+ Fish production statistics are very difficult to collect for the very obvious reasons of inadequate communication and improper keeping of yield records.

(3rd National Development Plan 1975 - 80 - Nigeria). A few others are the Bakolori Dam on Sokoto River, Funtua and Katsina Dam Projects. It is estimated that 1000 - 2000 fish fry/acre will be stocked and that five breeding centres of 100 acres each will be established.

Reservoir fishery is important for local development and for national protein production. Because of its importance, commercial fishery is integrated in the Kainji Dam which is primarily for hydroelectricity. The reservoir when filled creates a lake of yearly maximum dimensions of about 480 sq. miles and 165 ft. deep. About £500,000 was used to clear 100,000 acres of bush in the inundation area to remove obstructions and obstacles to fishing gear.

With this reservoir fishery development it is intended that the riverine fishermen should convert into effective reservoir fishermen. The way of aiding these fishermen is to be determined by the government. Most likely it would be by supply of gear to fishing boats to fishermen co-operatives.

<u>Customary fishing rights</u>: Fishing in the big and open rivers is public. This is often done with a variety of fishing gears - traps nets and longlines, some of which are shown in Figs. 12, 13 and 14. Customary fishing rights exist in small rivers and swamps in particular. There are two types of fishing grounds - perennial and intermittent pools.

The perennial pools normally retain water throughout the year. Each perennial pool is privately owned. No person has the right to fish there without the permission of the owner, who can loan or rent it out. During the heavy rains when the pools become part of

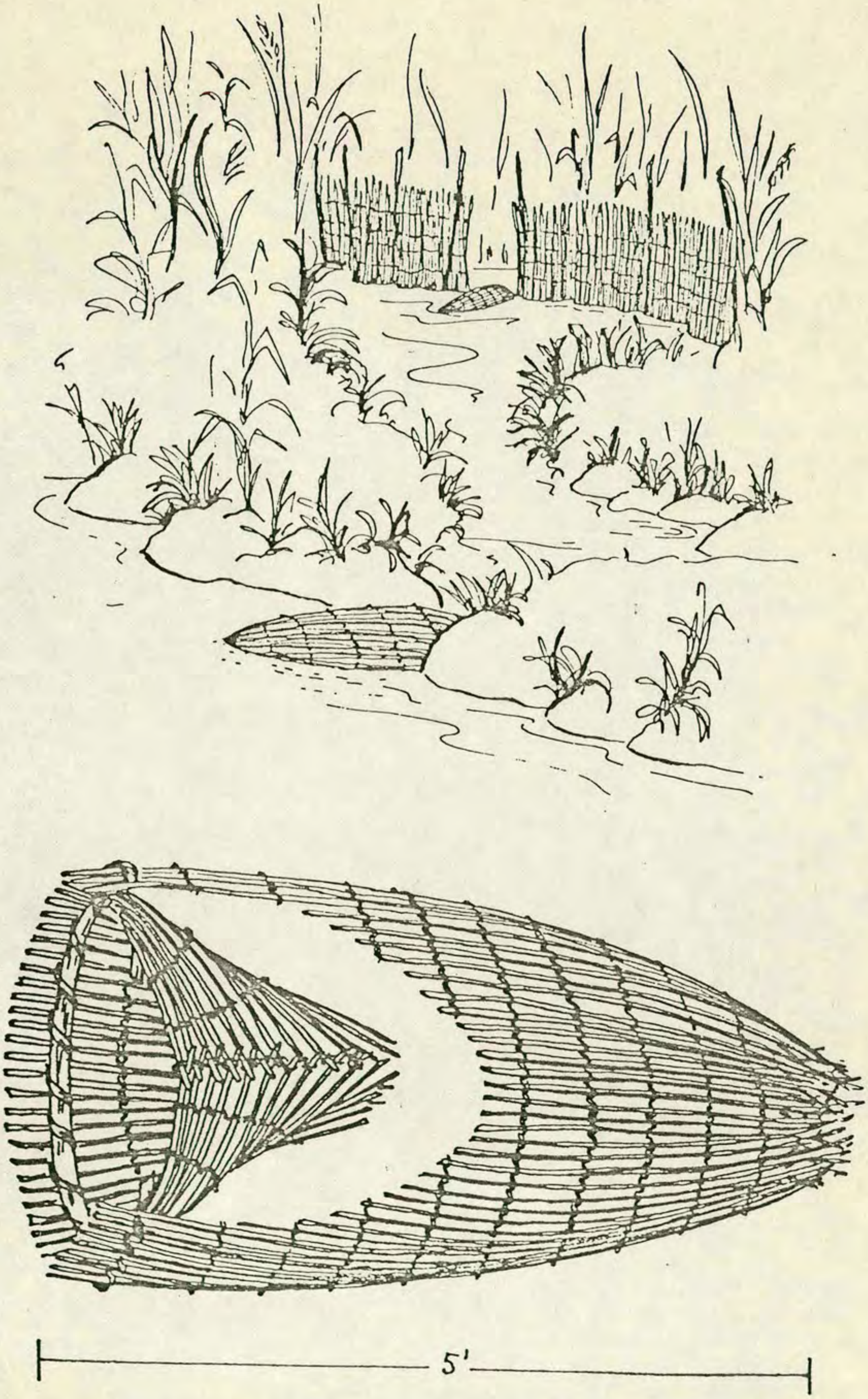


Fig. 12. Fish trap (Suru). Traps set in a stream (above).

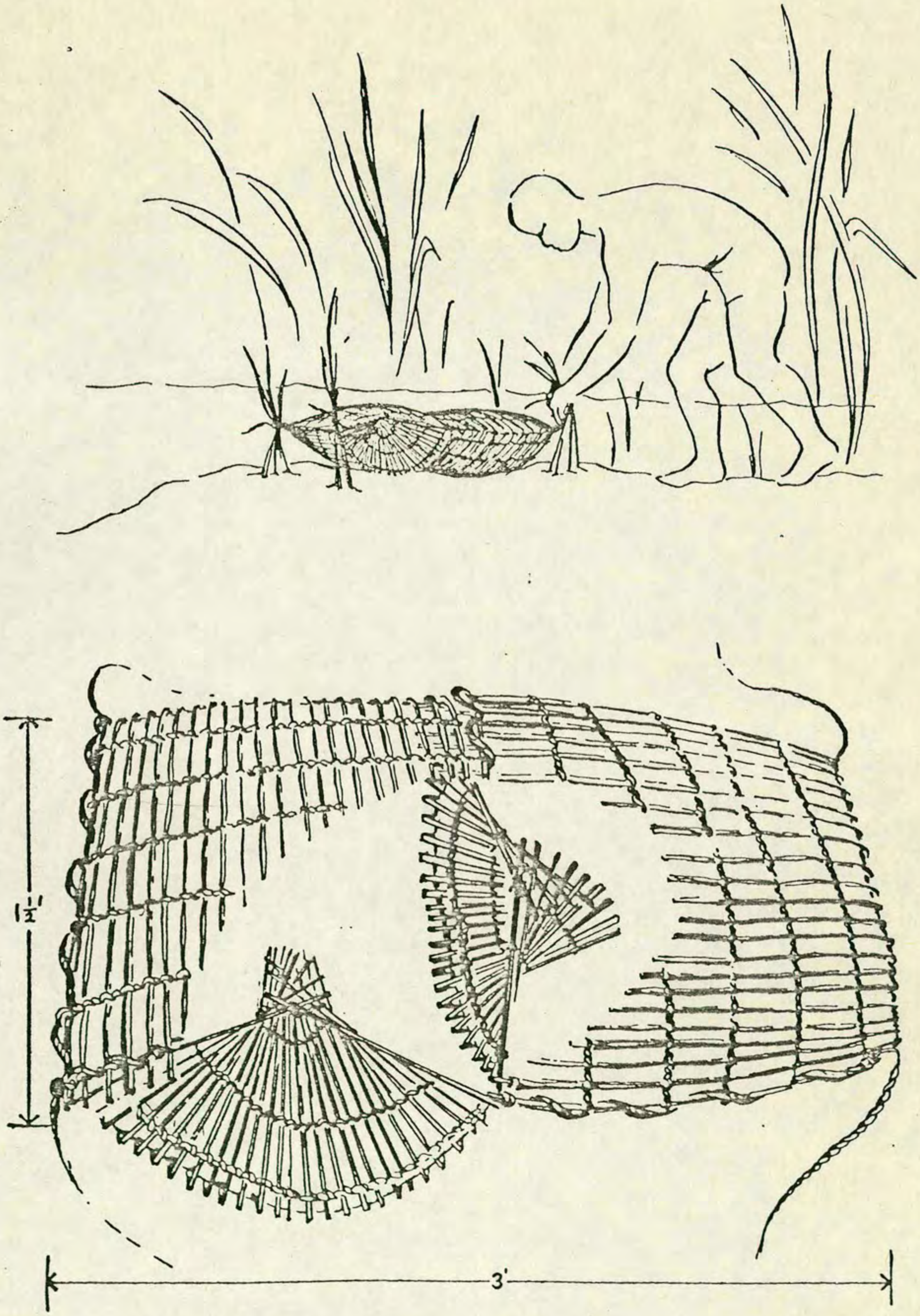


Fig. 13. Fish trap (Undurutu). Above, setting of the trap.

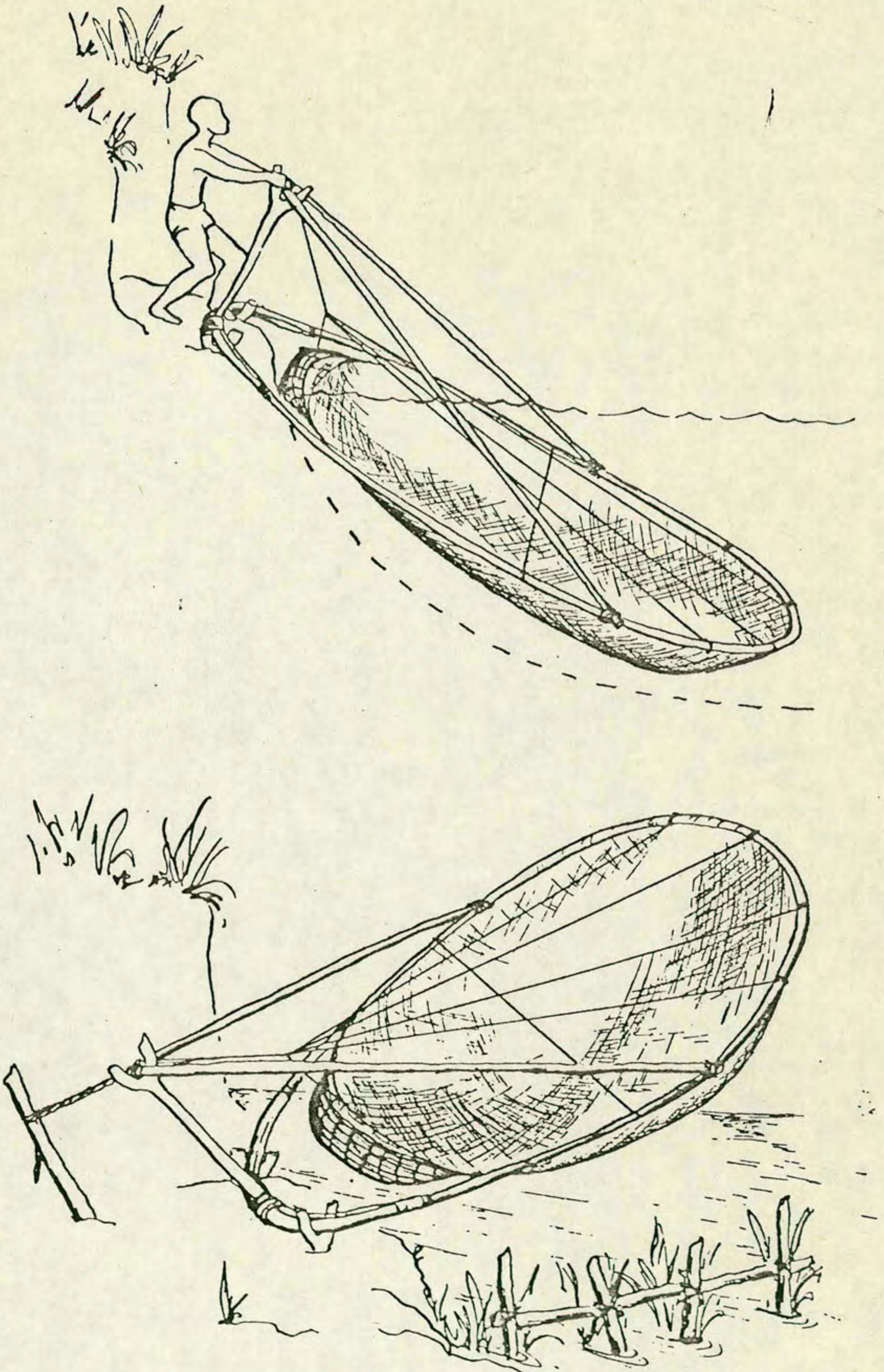


Fig. 14. Liftnet and it's operation.

the flood plain, fishing becomes public. Once the river recedes and the pool is formed, fishing right claim is asserted again. The pool formation corresponds with the dry season i.e. from about November to May/June each year.

Intermittent pools i.e. those pools that dry out months after the white flood has receded, are also privately owned. Fishing rights could be to an individual or a family.

There is a lot of area restriction with regard to fishing. Tribes, clans and even families have fishing boundaries with regard to swamp fisheries. Trespassing is a serious offence and can breed ill feelings.

Traditional rulers settle problems arising from swamp ownership and fishing rights by reference to native customs. The claim of ownership and customary fishing rights have existed probably because Federal, State or Local Authority Laws have not in any way given thought to protection of fisheries as an entity. Protection of Nigeria's wild life is provided for in the Wild Animal Preservation Laws of the former Northern, Eastern and Western Regions. These laws, though retained by new States, are obsolete and defunct. They were formulated on a philosophy different to what Nigeria should have i.e. a philosophy based on preservation and management with the objective to production in order to satisfy on a long term the food demand of the masses.

Legislation: With developments, the benefits of fisheries and the need for their management and protection were realised. Sea Fisheries Decree, 1971, was passed to protect the fish and the sea resources on Nigeria's continental shelf and in her territorial waters from the actions of unscrupulous foreign fishing vessels.

After the Sea Fisheries Decree 1971, it was proposed that a similar decree be promulgated in respect of inland waters, for the administration, management, protection, preservation and improvement of their resources and of fishing and fish industry. In the Draft Memorandum on Inland Fisheries Decree (WHICH WAS THE ONLY SOURCE OF INFORMATION AT THE TIME OF WRITING THIS THESIS) it is proposed that a Federal action should provide a uniform set of legislation, protect water, conserve fish, adopt a rational method of exploiting fishery resources, regulate the activities of all engaged in fisheries and govern fish industry irrespective of the political structure of the country. The rivers normally should be subject to State legislation. But since they flow inter State, a uniform set of legislation is necessary to protect one State from the actions or lack of actions of the other in matters concerning fisheries. It is also to protect fishermen who cross State boundaries in the lawful capture of fish. Furthermore, a uniform legislation is aimed to prevent pollution by poisonous products of industrial processes in one State, which is not very interested in fishing, from destroying the fishing downstream in another State where fishing is a very important source of revenue and employment.

The proposals in the Draft Memorandum just like the United Kingdom Fisheries Acts, prohibit the use of poisons, explosives and other harmful means of taking fish from the water except where specifically permitted for research purposes.

It prohibits the establishment of dams, weirs and other obstructions that can hinder free movement of fish in water. The decree when promulgated should control, regulate the building of dams, weirs and fixed engines.

It should provide and equip operational vessels or plants and grant financial assistance for research and experiment, and to co-operative societies for massive fish production. It should also encourage, maintain, and promote by financial assistance or otherwise, those services necessary for collection, collation and dissemination of data and statistics on fishing and the fishing industry.

Discharge of any chemical substances, drugs, poisons or any noxious or polluting substances in any waters frequented by fish or that flows into such waters is strictly prohibited.

The Minister or Commissioner of Agriculture and Natural Resources should be empowered to make regulations. The decree should empower him to reorganise, develop, protect and regulate fishing and fish industry. In doing so he should have regard to the method of fishing and regulation of size limit of fish to be taken out. The issue of fishing licence and fishing vessel licences, is the duty of the Minister.

The Minister/Commissioner should regulate or prohibit the export or import of any live fish or other aquatic animals, their eggs or their young ones. The regulation of prices and grades, methods of analysis and testing of any fish or fish product; establishment of standard of quality for fish and fish products should be the duty of the Minister.

According to the Draft Memorandum, the Federal Legislation should empower the State Minister/Commissioner in charge of fisheries to make regulations as may be expedient to the State but with due regard to the Federal Inland Fisheries Decree.

Should the Draft Memorandum be accepted without further reviews, there could be a possibility of some flaws in the Inland Fisheries

Decree, due to omission.

(i) Provision of fish pass or any form of passage where practicable, for commercial and migratory fish in waters affected by obstructions e.g. dams and weirs is omitted.

(ii) Protection against illegal fishing and pollution should cover all waters because of their uses - domestic and agriculture and the flow system which is inter State.

(iii) Pollution prevention as mentioned in the draft should be made to apply to all waters since no extensive studies have revealed as yet the waters that support very commercial stocks of fish.

(iv) Sewage and effluent treatments are not given prominence. Now that the industrial revolution is on Nigeria's threshold, there is need for an early fight against pollution and its harmful effect on fish stocks. Industries should be made to provide means of treating their effluents before discharge into water. Where this condition is not satisfied, they should be refused the licence to operate.

(v) Definition of the waters regarded as inland is not made. This would remove the doubts as to the fate of the intermittent pools formed after flood plains, which though form breeding grounds for fish in the rainy season, may dry up during the hot dry season.

(vi) No mention is made of setting up administrative or legislative machinery to enforce the legislation concerning fish stock protection or the promotion of cleanliness of the inland waters. The fisheries staff of the Ministries of Agriculture and Natural Resources in Nigeria have not been given the authority to perform all the functions necessary for upkeep of fisheries and prevention of pollution as have the bailiffs of regional water authorities of England and Wales and Fishery boards of Scotland and the river inspectors of the local purification boards of Scotland.

While offering no excuse for the vital omissions and other unforseen shortcomings, the draft has probably been narrowed by the very limited scientific knowledge of the local fish stock and the purpose for which the fish are being conserved, that is for food rather than for recreation.

Chapter 7

PROBLEMS AND RESTRAINTS IN FRESHWATER FISHERIES DEVELOPMENT IN NIGERIA

At times industrial, agricultural and other developments of a nation do suffer some set backs which are generated, more often, by the nation's economic status or shortage of specialists in the respective fields. Low level of civilization and political instability could as well contribute to set backs. Nigeria like any other country is prone to set backs, more so now that she is developing.

Freshwater fish production is yet to reach its target in Nigeria. The annual effective fish demand is currently estimated at about one million metric tons. The highly unsatisfied market for fish is due to the problems and constraints hampering development of freshwater fisheries:

(i) Absence of legislation for protection of fish stock and their environment: Nigeria needs effective legislation to protect freshwater fisheries from the bizarre actions of native fishermen. The absence of legislation has aided illegal fishing methods and the undirected service of the fisheries section of Ministry of Agriculture &

Natural Resources. There should, also be legislation to protect the rivers from being polluted. The fisheries staff and any other appointed persons should be empowered by the legislation to administer and manage fisheries accordingly and where necessary take legal proceedings against offenders. Until this is done, the value of inland fisheries would not be appreciated.

(ii) Poor Communication:

This is a major handicap. It has greatly hampered fisheries development in the interior. Poor or absence of roads and lack of river crafts to sites, cause distress to persons charged with fisheries functions. Fish distribution and marketing are badly affected by this. Middle men who are able to make their way to the producing areas capitalise on the misfortune of the unable by raising market prices.
Most fish caught in the coastal and creek areas suffer deterioration due to lack of transportation to the consuming centres.
Level of illiteracy is higher in the villages and rural areas. This makes communication between a staff, perhaps a non-native, and the natives difficult. Language problem could contribute to the slow rate of fisheries development. Statistics collection suffers too.

Fisheries laws could be contravened out of ignorance by the natives due to poor communication. They therefore deserve to be taught to keep the laws in the language they understand.

Culture and tradition due to complete isolation from other parts of the country could hamper fisheries development. Natives may insist on the outmoded and unproductive system of fishing and rearing fish as the best way known to them. Change to new culture may be difficult and resisted.

There is no communication of fisheries project results between states. It has not been possible to monitor adequate information on fish landings, catches, distribution and marketing and production potentials of the streams, lakes and rivers in Nigeria. This has rendered ineffective, development and management plannings throughout the country.

(iii) Inadequacy of funds:

This is also reflected in sea fisheries where heavy capital outlay is required for establishment of infra structures and purchase of fishing boats e.g. trawlers for off-shore fishing.

In the artisanal sector, indigenous fishermen find it difficult to finance heavy fishing activity because of their limited financial resources. The vessel used by this sector is canoe. Although canoes are comparatively cheap, sturdy, easy to beach and maintain, they have a limited payload, range and capsize easily. Outboard engines and fishing gear are expensive principally because of imposed import duties. Because of the expenses in the purchase of modern fishing equipments, local fishermen prefer restricting themselves to the outmoded, native and unproductive gears - traps and locally woven nets that easily lose their tensile strength after a short use.

Extensive fish culture development has greatly been hampered by lack of funds and proper economic evaluation of its benefits. This has reduced the wealth of information on fish culture and the availability of fish seeds required by prospective and intending fish farmers.

(iv) Inadequacy of trained manpower at various levels:
There is need for trained personnel at various levels to handle the problems in the development of fisheries. The combined efforts of fishery biologists, fishery scientists, conservationists, other technical staff and administrators make for proper development and management of fisheries. At present the level of trained manpower for freshwater fisheries in Nigeria is low.

(v) Lack of Scientific knowledge of the endemic stock:
This has resulted in the improper development and conservation of freshwater fisheries. It is also instrumental to the haphazard way the fisheries are administered. The biology and scientific knowledge of endemic stock are basic in the formulation of any fisheries law. This ensures proper and adequate protection just as the United Kingdom Fisheries Acts took into consideration the biology of the fish being protected.

(vi) Extension Service:
Extension service, which is meant to bring the benefits of modern fishing and application of fish culture techniques to the fishermen and fish farmers, in the rural areas, is weak

and poor. The service is to educate the local communities on the need for fish stock management and conservation by keeping to modern techniques and abiding by any existing fisheries laws. The poor situation of this service could be attributed to poor communication, absence of strong and effective legislation, weak administration and inadequate funds to run the service.

(vii) Lack of effective fishermen/fish farmers cooperative:
Individuals interested in either fish farming or fishing are generally not capable of providing security to obtain financial loans from the government. Therefore, cooperatives of viable fishermen/fish farmers are vital in order to benefit from government financial assistance schemes. These co-operatives once qualified for the loan are bound by existing legislation for freshwater fisheries in the country. They would also serve as watch dogs for individuals who might seek to ruin fisheries in any of the waters in the country.

(viii) Ignorance of conservation education:
A local fisherman who is after a catch may not appreciate the need to adopt measures to conserve fish stock for the coming generation. His level of intelligence, illiteracy and ignorance of the law make it hard for him to think of measures to improve and possibly increase the stock of fish in his environment.

It behoves the government to set up fisheries schools to teach and educate the local communities on the need for conservation.

Alternatively subjects like fisheries and natural resources management could be taught in the adult education classes which have spread to the rural areas of the country. Young Farmers' Clubs and schools should be made to include conservation education in their curricula.

The traditional rulers should warn their subjects of the consequences of wanton fishing, teach them the need for conservation, its role and overall benefits.

Propoganda system of information dissemination should be adopted by the Information Division of Ministry of Agriculture and Natural Resources. Leaflets showing cartoons and benefits of conservation measures should be printed and distributed by the extension service to the public, particularly among fishing communities. It is the duty of the extension staff to teach, instil belief and confidence in the local people by practical demonstration and the conscientious way fisheries programmes are handled.

Chapter 8

A CRITIQUE OF THE UNITED KINGDOM METHODS FOR USE IN THE MANAGEMENT OF NIGERIAN FRESHWATER FISHERIES

Freshwater fisheries in the United Kingdom are conserved and managed to a variable degree. Coarse fish receive much less attention than the non-migratory trout and the anadromous members of the salmonid family e.g. salmon and sea trout.

Salmon and trout are very much valued. Because of their importance many research studies have been made to know more about their life-cycle - reproduction, feeding and migratory habits. The results of these have helped in instituting the conservation measures presently adopted.

There are certain basic facts in any conservation measures. First, the importance of what is being conserved. Fisheries are important to many for the food, recreation and economy which they offer. To some it is important as an item of food while to others it is important as a source of recreation.

The objective behind freshwater fisheries conservation in the U.K. could be said to be dual; for commerce and recreation. The management of inland water fisheries benefits the anglers and angling clubs who pay for the satisfaction derived from sport fishing.

Sport fisheries in the United Kingdom are countrywide and the main quarry is the trout - Salmo trutta. These are good sport fish and the method laid down for catching them is by fly fishing.

The management of freshwater fisheries irrespective of the species of fish, in Nigeria, is primarily for food. About 95% of the angling done locally is for the purpose of subsidising the protein in family diets. Priority is not given to recreation and there are not any organised angling clubs as in the U.K. Because of the purpose for which angling is done, all sorts of baits are used to lure the fish.

Nigerian waters do not contain trout for geographical reasons and emphasis is not laid on a particular group or family of fish as on the salmon and trout in the U.K. However some species of fish are liked amongst local communities in Nigeria. This is often due to their availability, cheapness or palatability. Because of the circumstances surrounding Nigeria's freshwater fisheries, there is not strictly a regulated method of fishing. Although the use of poisons and other harmful methods are abhorred, communities freely use other various equipments - traps, nets and hooks to grab as much fish as possible from the water.

Another basic fact is the conservation concept. This is variable, confused and considered differently by groups of individuals and countries. It could be dependent on the socio-economic systems of the community or country. The socio-economic attitude in the United Kingdom (sea fish for food and inland fish for recreation as commonly adopted) has presumably lessened the pace of development and diversity of fish stock conserved within the inland waters. This attitude might be responsible for the late enthusiasm in research studies to achieve a better breed of fish through genetic improvement. The belated enthusiasm could have resulted in the low yields of freshwater fisheries (including aquaculture) and lack of expansion in the positive direction for large scale production. It has caused the importation of about 323,000 coarse fish (carp, tench, bream, roach), 900,000 aquarium fish, 2.2 million brown and 5.78 million rainbow trout eggs into the United Kingdom.

Sea fish controls the fish market in the U.K. and technology in deep sea fishing has helped to sustain sea fish supply for food. It is likely that technology and other factors e.g. increasing rate of industrial, population expansion and their attendant problems of space and pollution contributed to the poor rate of development of freshwater fisheries.

The influence of socio-economic nature of a developing country like Nigeria, on conservation concept is different. There is a big urge for freshwater fish for food. This may be borne out of sentiment or circumstance e.g. absence of sufficient facilities to exploit rich resources of the sea. Where facilities for sea fishing are poor, greater attention is given to inland waters for fish supply since fishing in the inland waters do not require the sophisticated gear system as used in sea fishing. At this rate the only option is conserved for its usefulness - food, income and employment.

The strict definition of conservation is complicated and generally difficult to put into effect especially in rural and developing areas. If followed rigidly through legislation, the rigours of the law may be too hard to apply because of the existing circumstances within a community. On the other hand, the bodies in authority may be fragmented and scattered thus still making it difficult to obtain a joint action and strictly apply the conservation principles.

In the real sense, application of conservation methods of freshwater fisheries depends on the knowledge of the stock being conserved i.e. what stocks are present and their benefit to human and animal communities; estimated size of stock based on previous work and statistics; biology of the fish stock and its ecology.

Armed with this knowledge, fisheries could be regulated. Fisheries regulation in conservation helps to maintain an orderly fishing, identify fishermen by licensing and ultimately helps to enforce fisheries laws.

Freshwater fisheries, like any other valuable natural resource, are usually conserved by legislation. For all intents and purposes, the U.K. Fisheries Acts were originally passed for salmon and sea trout conservation. Later these Acts were extended to cover freshwater fisheries. The Acts and the management methods are basically tailored for: (i) The types of fish in the British Inland Waters.

(ii) An objective (already defined) and an advanced nation whose fisheries are already established and managed to a reasonably high level.

The consideration of the application of the management methods for Nigeria inland fisheries should therefore be cautiously made.

The Nigerian field is different. It is tropical with its characteristics and fish stock. As Lowe-McConnell (1975) noted, tropical fish communities within one habitat are known for their high diversity and complexity more than in a temperate habitat. Above all, Nigeria's fisheries are in a developing stage. The application of the U.K. methods therefore should not be carried out in isolation from these facts. It should also consider Nigeria's objectives in freshwater fisheries development, her level of development and economic background, her administrative and political structures.

Strict application of rod and line, net and coble as the only means of fishing inland waters would not favour local communities in Nigeria. Rod and line should operate with other fishing methods e.g. nets and traps because rod and line alone would not fetch enough fish for an average family. It would not effect enough removal of fish to avoid over population which could easily occur in tropical waters where under exploitation exists. This could easily happen because of fast growth and high reproduction rate of some tropical species of fish e.g. Tilapia sp. and Alestes sp. Rod and line fishing is time consuming and uncertain. It may only succeed in removing small and juvenile fish in tropical waters.

The system favours the United Kingdom since it is for recreation, natural recruitment of trout is poor because of limited favourable spawning grounds and the slow growth rate of fish which is caused by the climate and poor water conditions of some oligotrophic and dystrophic lochs and ponds.

Traps, weirs and fixed engines are prohibited in the rivers and estuaries by the United Kingdom Fisheries Acts. This would not favour swamp fisheries in Nigeria. Swamp fisheries are often common in the tropical rainforest zones. These develop from flood plains which result after rivers and streams have overflowed their banks due to heavy and prolonged rainfalls. Netting of swamp fisheries are usually difficult and unsuccessful because of the presence of plants and stumps of trees. Traps and other gears illustrated in Figs. 12, 13, and 14 could be the only effective and inexpensive method of fishing in the swamps for a local and poor community.

The use of nets with mesh size not less than 2" x 2" was instituted to allow for the escape of immature and small size salmon and trout. The application of this, would not favour Nigerian fisheries because of the diversity (type and size) of the fish stock in her inland waters. The gill net is popularly used in Nigeria but of course it has its problem of selectivity, which at times might not favour a developing fishery. Although, Banks et al (1965) suggested, for administrative convenience, a 30 mm bar gill net that will catch a range of small genera, it is not possible in the present state of knowledge of Nigerian fisheries to state whether this will give the maximum yield to satisfy an objective. Fish of Synodontis sp. do a lot of damage to gill nets of small mesh. For this reason fishermen may prefer to work with bigger mesh size nets to avoid further damage. This attitude may change the face of fishery. Particular sizes and species of fish are taken because of the fishery which has naturally evolved into large-mesh gill netting.

Some tropical fish are naturally small and poor in growth. With 2" x 2" mesh size net they may never be caught. This could result in their abundance if they are not commercially important, and predatory fish remarkably absent. Diversity in fish stock would therefore be a problem in establishing a net mesh size unless it is done for particular genera of commercial importance.

In the circumstance it would be better to regulate on fish-size with reference to certain genera of importance whose biology, growth and reproduction rate are known. The local fishermen could be more knowledgeable in this than an office fisheries staff.

Close seasons are for the protection of the fish from being taken at the time of spawning. It is also to protect the young fish and spawning grounds from the activities of anglers and fishermen.

Enough scientific knowledge is yet to be acquired about the feeding, spawning and migratory habits of Nigerian freshwater fishes though it is known that some fish (e.g. Alestes spp.) show seasonal abundance i.e. when the newly recruited migrate to the open waters where they are frequently seen in shoals. Because of adaption to lacustrine conditions some tropical fish do not present any dramatic examples of migration. However, Labeo spp. make what are occasionally spectacular migrations into affluent rivers in order to spawn (Lowe-McConnell 1975). The cichlids e.g. Haplochromis quadrimaculatus of Lake Malawi and Tilapia macrochir are known to undertake breeding migrations (Fryer and Iles, 1972). It is not until enough knowledge of spawning migration is acquired that the institution of close seasons would benefit Nigerian inland fisheries.

On the other hand close seasons would be unrealistic where freshwater fisheries are for food and the only source of protein to fishing communities in riverine areas where animal protein is scarce or almost lacking. Also many full-time inland fishermen would temporarily be out of work and without any income to sustain them throughout the period of the close season.

Instead a quarantine could be established. Some zones or areas of water suspected to be spawning and feeding grounds for adult and juvenile fish of commercial importance respectively could be cordoned off. Fishing in such bodies of water should be made illegal. For a meaningful protection the local fishing communities likely to violate the law should be charged (though subordinate to the Fisheries Staff of the Ministries of Agriculture & Natural Resources) with the responsibility of protecting the fish in these waters. The waters should only be fished at a stipulated period of the year. This will offer sport fishing as well as fish for food as is the case with the 'Argungu fishing festival' in the Northern Nigeria.

It could be possible to consider the application of close seasons and times for fishing in big, open and important rivers and streams and not in the freshwater swamps. But how much would this favour the fish. Most fishings are done in the small rivers and swamps which contribute a big percentage of the fish produced locally. From the little knowledge of spawning behaviour of tropical fish, swamps, semi-stagnant waters and small rivers are good spawning grounds. If the spawning grounds are defiantly fished by local communities in the hinterland, natural recruitment would be disrupted. The aim of imposing close seasons for the open waters would, then, be defeated since the swamps and the small rivers form a major source of fish recruitment to the big and open waters.

The system of fishing licence established by the Salmon and Freshwater Fisheries Acts in England and Wales could be applied in Nigeria. By these Acts the regional water authorities issue fishing licence for salmon and trout and freshwater fish. The licence is only valid within the catchment area of the water authority that issued it.

Fisheries administration in each political state in Nigeria should adopt a system of licensing which should only operate in her state. By licensing, fishermen are identified, fisheries are regulated and better records of catch and fishermen are maintained. It would yield some revenue for the State Government as well. This system would be different from the Scottish where no fishing licence, for freshwater fish, operates. Proposals for its introduction were recommended by the Hunter Committee (Cmnd. 2691, 1965) but have not been implemented in the Freshwater and Salmon Fisheries (Scotland) Act 1976.

Licence categorisation in England and Wales because of the quality of water and fishing should not apply in Nigeria. The licence charge should be uniform and seasonal i.e. for a year. Monthly licence or day permit should not be adopted since the conditions warranting this - angling based tourism - do not exist in Nigeria at present.

There is no provision for government financial assistance to fish farmers in the U.K. as there is in some E.E.C. countries. This apparently spells out the limited desire to develop freshwater fisheries for food and contributed to the few numbers of freshwater fish farms in the U.K.

Provision for assistance to private or co-operative fish farmers or fishing units is necessary in Nigeria. This is a way of improving and upgrading the artisanal fisheries on which the greater population of Nigeria depends. It will create employment opportunities, stop the drift of youngsters from the rural to the urban areas and make for the development of the countryside.

The establishment of Rivers Pollution Acts, separate from fisheries Acts, has further enhanced the protection to fish stock. A similar Act would benefit a developing country against possible dangers of pollution which is often the aftermath of industrial development and lack of foresight for an early need to protect the environment. It is generally a common practice to discharge polluting matters especially domestic and human wastes into rivers, streams and estuaries in some developing countries. This is done on the grounds that flowing waters serve good dumping grounds and that natural purification, after quick decomposition, particularly in the tropics, would take place. The rivers are regarded as the most convenient dumping grounds in the absence of sewage treatment works. The danger to fish life, this causes, is not often appreciated.

Industries are developing fast in Nigeria and an early institution of an Act to control and prevent water pollution would serve Nigeria better than having to institute an Act when pollution has started to occur. Just as Jackson (1966) noted when discussing fisheries conservation:

> "...... it is sounder practice when starting the brand new fishery of a newly impounded lake to commence with conservation measures in force and remove or lighten them as experience shows, but with the precedent of their once having been there remaining in case of future need, than attempt to impose them afterwards when custom, usage and vested interest have grown up in the fishery. Imposition may then be resented whatever the need and be in general more difficult".

This would preclude chances of harm to fish and damage to water resources. Industries being aware of the need to maintain clean waters would establish effluent treatment works alongside their industries or find means of treating their effluents. Alternatively, local authorities supported financially by respective State Governments should establish effluent and sewage treatment works to receive the industrial and domestic wastes. As in the United Kingdom, industries should pay for services rendered by local authorities' sewerage works.

By adopting the provisions of the Rivers (Prevention of Pollution) Act 1951 of the U.K., the habit of poisoning waters with plant extracts and chemicals or blocking of water to drain it out for the purposes of fishing in Nigeria could be controlled or stopped.

Establishment of punishments for offences against the Acts would serve as a deterent. The penalties in a developing country should rather be more severe and could be reduced with time after the legislation has been well taken.

The Legislative machineries, apart from being involved administratively and technically in fisheries are also concerned with water conservation, pollution prevention and control, inland drainage and recreation. This is so because of the multipurpose functions water schemes serve in the United Kingdom.

Water supplies are mostly by surface reservoirs in the United Kingdom. These reservoirs are often multipurpose e.g. hydro-electricity, fisheries, water supply (industry and domestic), recreation and drainage. These are administered by Water Authorities, River Purification Boards, National Water Council, and Fishery Boards who exercise multiple functions.

In Nigeria a different level of administration exists. Fisheries are treated separately from water schemes and by different organs. Fisheries administration is the responsibility of the State or Federal Ministry of Agriculture and Natural Resources while water supply is taken care of by State or Federal Water Board. State organs take charge of their own projects within their political boundary only. The Federal organs have functions and establishments within the States throughout the country. The exercise of their functions, are only limited to federal establishments.

There is no relationship, functionally, between fisheries administrators and Water Board. This is due to the water supply scheme operating in Nigeria. Water supply whether domestic or industrial, in Nigeria, is mainly by bore-holes and elevated tank reservoirs and is administered by Water Boards. In some rural areas, water supply is by surface (streams and rivers) and underground waters. Water Boards do not have any authorities over these waters, whether they serve for fisheries or not. There is, therefore, no cause for functional relationship between fisheries administrators and Water Board.

Until multipurpose surface reservoirs are established or the authority of the Water Board extended to cover all the waters (bore-hole, surface, underground and reservoirs) in Nigeria, it would be difficult to establish the type of administrative bodies in the United Kingdom. As long as water developments are unidirectional i.e. water for water supply only, fisheries administrators and the Water Board will always operate as separate entities, and at different levels. They will have nothing in common.

An integrated system would aid the establishment of research centres and academic associations such as Freshwater and Marine fisheries laboratories, Fish Pathology Units, Freshwater Biological Associations and Nature Resources (Conservation) centre. These units would co-operate with administrative bodies and government functionaries in the maintenance of water quality, environmental protection and fisheries and in solving other problems of mutual interest. By such an integrated effort, an atmosphere for a healthy and progressive development and conservation of Nigeria's natural resources would be created.

Although Scotland has some laws peculiar to her, in general other laws which uniformly apply have guided the different administrative and management machineries in England and Wales and Scotland to a common goal. The Water Authorities and the River Purification Boards, though have their own catchment areas and are separate bodies, are guided to similar objectives by Rivers (Prevention of Pollution) Acts.

As in the United Kingdom, a set of legislation which would give a uniform directive to the administrative organs, even though they are separate bodies, should apply to all the States in Nigeria despite political and geographical differences. The legislation should be basic enough to allow for recognition of the importance of each administrative organ's duties. This would ensure a uniform system of development and management of resources to the advantage of the country as a whole.

Private fisheries as in the United Kingdom apparently would not favour Nigeria. This system of private ownership of waters could stifle the efforts of administrative bodies in the effective management of these waters. Private ownership of fishing rights, except for artificial populations i.e. population consisting entirely of hatchery fish, in certain waters e.g. farms, lochs and ponds used for production and research, should be abolished. Legal ownership of lands adjoining the rivers, streams and other waters may hold provided the problem of creating access road to the waters, for public fishing, is solved. Financial compensation could be made to land owners or special fishing rights granted them to fish only in the water passing through their own portions of the land. By this policy, private landowners would not deny access to the public wishing to fish.

Private fisheries in the United Kingdom are most commonly put and take. The ideology in this type of fisheries and the individual interest lurked behind that feeling of ownership do not allow for proper development and diversification of interests. Unlike public fisheries, private fisheries tend to concentrate more on a particular species of fish e.g. non-migratory trout - brown and rainbow trout especially. In such circumstances the interest of the owner might be first before that of the public who might want other species of fish. ~~It looks as the fish species necessitated the current peculiar method of fishing.~~ The restriction of anglers to fly fishing only is a common practice on many trout waters. ~~is nationwide.~~ This could be time consuming because in some waters where the fish (e.g. brown trout) are much older than three years, they hardly rise to flies unless the environment is so poor that it will not sustain the fish population, food-wise. (Thorpe, pers. comm.). There is, however, one good aspect of this type of fishing i.e. it does not allow for a massive removal of trout from the water. It helps to protect and conserve the fish stock.

The policy of bag limit is applauded. But the policy of anglers returning their catch to water deserves a new approach. This policy plus the fishing style might have precluded the necessity at present for hatchery operations on a large scale since fish stocks do not seem to be fastly depleted. Return of fish to water helps to conserve fish. On the other hand, returned fish could die out of infection of the wound caused by anglers' hooks and rough handling by anglers. A good and unrecorded number of fish must have been lost by this method. Anglers should enjoy catching and eating the fish. By this, they are more aware of the value of their catch and they are brought nearer to real benefits of freshwater fish as a good source of protein and not for sport only. By allowing anglers to remove their catches, they become fully aware that their activities can have a detrimental effect on a fishery and so they try to adopt a sense of responsibility towards fisheries for their values.

The public fisheries system should benefit Nigeria more. This would give the scope for an early mapping out of the priorities of a developing freshwater fisheries. Public fisheries provide a wide range of types of water and species of fish. This is much unlike private fisheries. It allows for better administration, management, circulation of field work results and other information necessary for successful development of fisheries.

Because of the bilateral face of public fisheries, more money is spent by the nation to restore destroyed or depleted fisheries, upgrade the quality and quantity of fish stock thus improving and increasing fishing opportunities. New areas are opened and this extends public amenities to the interior. More hatcheries for maintaining, reclaiming, developing and creating of new fisheries are established. The use of hatchery fish will:

(i) provide the desired species and possibly the desired strains.

(ii) allow development of new strain with valuable characteristics e.g. fast growth and disease resistance.

(iii) minimise the possibility of unwanted species of fish in a body of water.

(iv) allow for easy stocking with required size, number and at the right time by the authorities in charge of fisheries.

This system precludes the possibility of uncontrolled stocking that can obtain in private fisheries or bodies of water privately controlled and administered, as in some reservoirs in England. By success of public fisheries, private hands could be encouraged to set up fish farms like the 'Farm Pond Program' in U.S.A. This program was initiated by the Department of the Interior to encourage and subsidize farmers to construct small lakes and ponds on their land for fisheries and amenity. There would also be better scope for support of cooperative fisheries projects, offer of expert advice to the public, on fish culture and fisheries management based on research and development results.

Investment of public money in supporting and creating public fisheries could bring considerable income to communities local to the fisheries. As more waters are opened and managed for fisheries, so too, fishing pressures become evenly spread and the public interested in fishing would be prepared to pay more, if need be, for licence.

In summary, some methods (both management and administrative) of conservation of freshwater fisheries in the United Kingdom could apply in the management of Nigerian freshwater fisheries. The application of the methods, however, should be made with regard to basic issues in Nigerian freshwater fisheries development:

(i) The objective: This should be mapped out as in the U.K. where it is primarily for sport hence the strictly regulated means of fishing.

(ii) Strategy and Policy: These should be defined, too, as in the United Kingdom where absolute overall priority is given to ensure optimum natural spawning to maintain stock. Enforcement of legislation, habitat improvement e.g. establishment of fish passes where necessary, prevention and control of: (a) pollution, (b) physical damage and (c) excessive water abstraction are strategic steps to ensure that salmon and trout and their habitats are conserved. Monitoring devices to provide basic information in the support of salmon and trout management programmes and artificial propagation contribute to the efficient system in stock protection, preservation and improvement.

(iii) Administration: Nigerian system should make for an integrated system of administration as in the U.K., where separate but related functions are in the care of an administrative organ. This could be achieved, not spontaneously, and without risk to her aspirations as a developing nation.

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APPENDIX

A CATALOGUE OF PRACTICAL TRAININGS AND PLACES VISITED (FIELD TRIPS) IN THE UNITED KINGDOM, DURING THE TWO-YEAR FISHERIES MANAGEMENT STUDIES IN THE UNIVERSITY OF EDINBURGH, SCOTLAND.

1975-1977.

CONTENTS

INTRODUCTION

In the course of my M.Phil studies in Fisheries Management in Edinburgh University, it became necessary that I should do a number of field trips to appraise fully the methods of conservation and management of freshwater fisheries in the United Kingdom.

These field trips involved practical trainings at and visits to some of the Boards, Authorities, Research Units (Government and private) concerned with fisheries. These bodies are concerned with fisheries either in the administrative capacity or studies through research programmes. The field trips as mentioned in the contents are of two parts.

Part A:-

This involves practical trainings and studies through active participation in the fisheries management procedures generally adopted for stock improvement, conservation and research.

Part B:-

Deals with visits to Boards, Research laboratories and places of varied interests in fisheries in order to be acquainted with their working procedures and research programmes. The visit also acquainted me with the administrative systems and achievements of these bodies directly or indirectly concerned with fisheries, water (pollution prevention and control) and other related functions.

Trip I

Fish Marking at Loch Fitty in Dunfermline - Fife 1-11-75

Loch Fitty lies in a shallow valley about 5 km to the north-east of Dunfermline in the county of Fife. It extends to about 65 ha. with an average depth of 1.98 m. and a volume of 1280 million litres of water as worked out through a bathy-metric survey in 1910. The main feeder stream is the Meldrum Burn from the south. The spawning facilities for brown trout - Salmo trutta are not good as the gravel in the Burn has been silted up through mining, quarrying and fire clay digging operations in the area for many years.

Game Fisheries Ltd. became interested in the loch in 1969. An ecological study of the loch was carried out. It was discovered that owing to environmental problems of weed growth, mine wastes and bottom silting, the loch became eutrophic and supported excessive numbers of pike - Esox lucius, and perch - Perca fluviatilis because of habitat changes. The Game Fisheries Ltd. wanted to develop this lowland loch as a trout fishery so the control of unwanted species of fish particularly pike was necessary. An application was made to the Secretary of State for permission for use of rotenone to clear the loch of unwanted species of fish. In August 1970, applying the bathymetric knowledge of the loch, and other precautionary measures to safeguard life in the low end of the loch and the outflow burn, the application of rotenone was made. Vast quantities of fish were removed in one week. The figures shown below are only those washed ashore by the prevailing wind. Many dead fish must have been sunk to the bottom of the loch or caught within the weeds.

Perch	about	1.84 tonnes
Pike	about	.75 tonnes
Eels	about	.7 tonnes
Trout	about	.2 tonnes

The loch now for 'put and take' fisheries, owned by Game Fisheries Ltd., was stocked in April 1971 and opened in 1972. Each year about 10,000 trout are caught by anglers who pay for the recreation offered by the Game Fisheries. There are more than four holding tanks for the initial breeding of the trout before they are put into the loch. In these tanks they are fed with dry pelleted fish feed. See Table 1 attached for the composition of the feed as used by the Game Fisheries.

The trout about to be put into the loch were marked using the jet innoculator (Panjet) and Alcian Blue 8 GX. Another method used was freeze branding. This involved the use of liquid nitrogen at a temperature well below -100°C and a specially built apparatus. Before the trout, mostly rainbow trout - <u>Salmo gairdneri</u> were marked, they were anaesthetised with M.S.222 for easy handling and quick marking. Caution was taken not to mark on the lateral line of the fish as this will likely affect the nervous system. Diagram 1, shows the marking positions as followed and Diagram 2 gives the geographical location of Loch Fitty.

There are many other ways of marking fish but the above methods have been used because of their simplicity and short term purpose, though the marking with Alcian blue has been known to last up to 18 months. The main objectives of fish marking generally are to find a way of estimating indirectly fish number and also trace their movement. The results obtained thus are applied in population

Table 1. BETA TROUT and SALMON DIET

Formula	Description	% Oil	% Protein	% Fibre	Vitamin A iu/kg	Vitamin D iu/kg	Vitamin E iu/kg
418	Salmon Starter	16.0	58	1.5	20000	2000	120
422	Salmon Growers	7.5	50	3.0	15000	1500	90
401	Sea Salmon	14.0	46	3.5	15000	1500	90
409/410	Trout Floating	4.5	40	4.5	18000	2000	30
417/419/420	Trout Growers	6.5	45	4.0	18000	2000	30
428	Brood Fish	6.5	50	4.0	27000	2000	45
441	Trout Fry 0-1	8.0	56	2.0	20000	2000	120
442	Trout Fry 2-3	6.5	50	3.0	15000	1500	90
413	Trout 4	6.5	45	4.0	18000	2000	30
414	Fish Holding Pellet	5.0	35	5.0	13500	1500	22.5

All Beta Trout and Salmon diets contain a permitted Antioxidant. "Pigmented" on the bag indicates the addition of a permitted pigment.

DIET SIZES

No. 0 for fish up to $1\frac{1}{2}$"

No. 1 " " " $1\frac{1}{2}$"-3"

No. 2 " " 3"-4"

No. 3 " " 4"-5"

No. 4 " " 5"-6"

No. 5 " " 6"-8"

No. 6 " " 8" and over

(COOPER NUTRITION PRODUCTS LIMITED)
(STEPFIELD. WITHAM. ESSEX.)

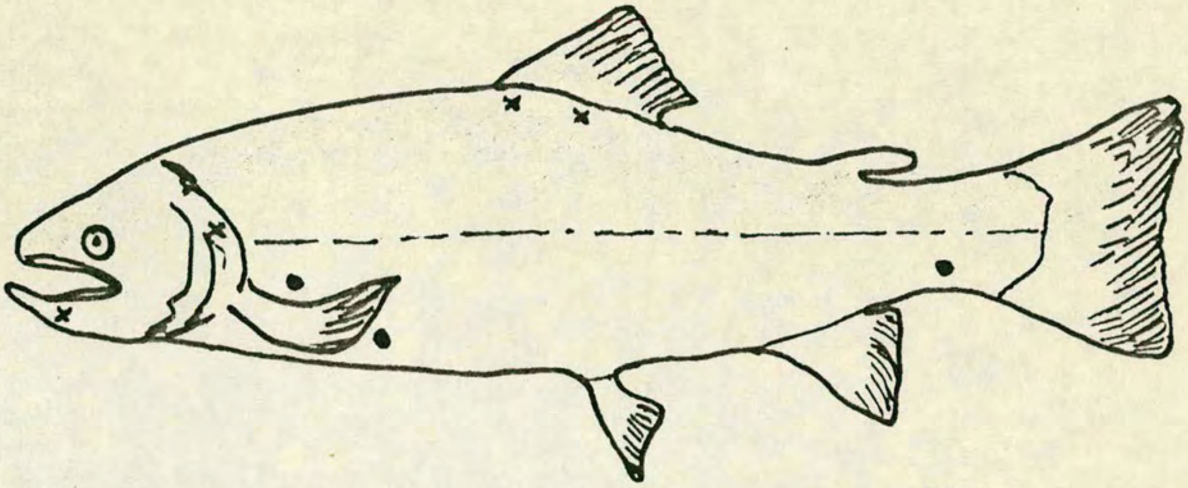

Diagram 1. Fish (Trout) showing marking and tagging sites.

KEY
● COMMON MARKING SITES
✖ COMMON TAGGING SITES

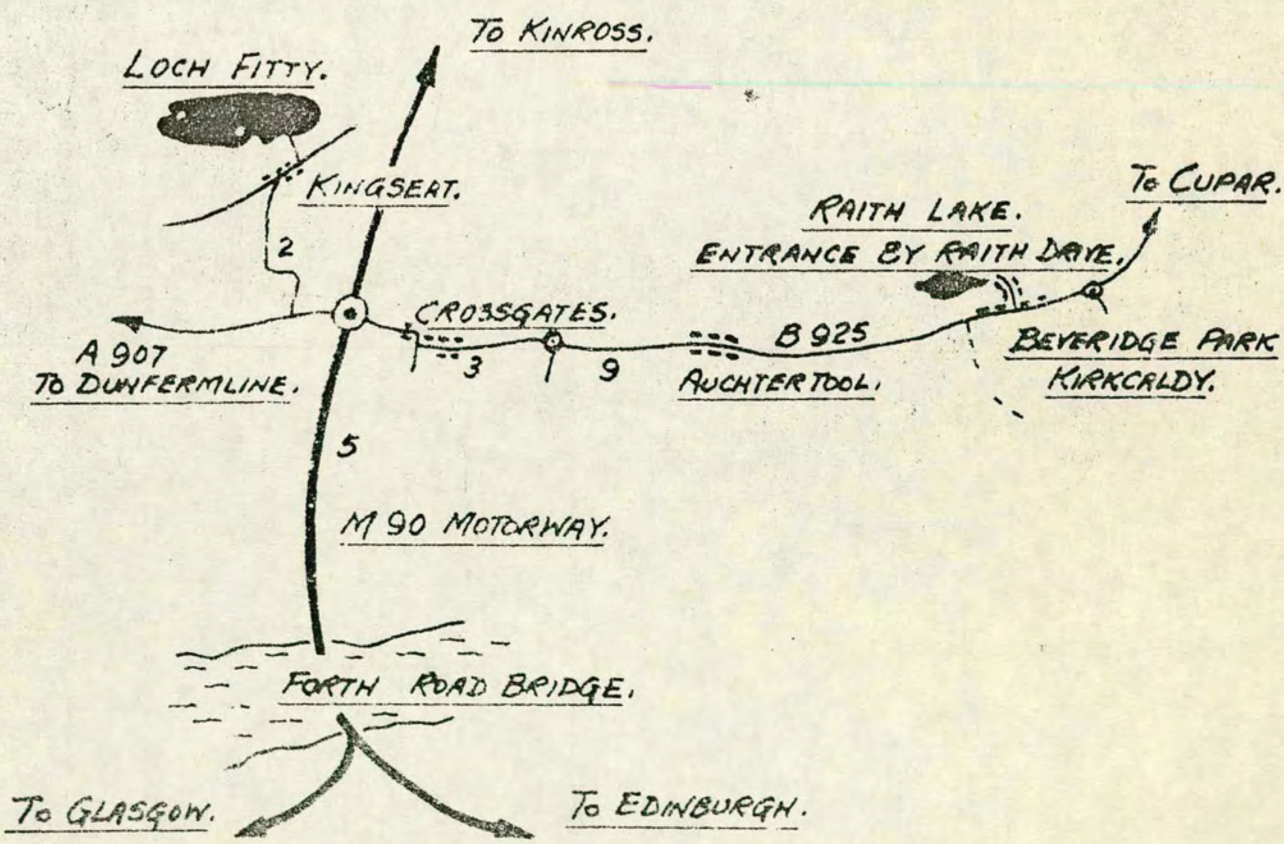

Diagram 2. A sketch showing the geographical location of Loch Fitty.

parameter (densities, mortality, exploitation and recruitment rates) studies. The results are also used for growth and age determination and fish behaviour study.

Trip 2

Seine Netting of Moorland Ponds at Meldon - Scotland 17-11-75

In the past years studies have been made of these moorland ponds which according to observations have not been particularly productive. The four ponds which are interconnected are for sport fishery. Some basic chemical characteristics of these ponds are as shown below. They have a pH range of about 5.9 - 6.5 and their alkalinity is low as well, ranging between 7.2 - 18.6 p.p.m. These ponds were stocked with trout (Brown and Rainbow) in the past years, 1973, 1974 and 1975. It was a mark-recapture exercise to find out the movement and mortality rates of the introduced fish. Attempts were also made to improve the productivity of these ponds by limestone ($CaCO_3$) and fertilizer application.

On 17/11/75 four hauls were made from a rowing boat with a beach seine net. A total of forty-five trout (Both Rainbow and Brown) were caught. They were mostly rainbow trout. Length measurement was taken of all the caught fish. It was observed that nearly all the rainbow trout were heavily infected with eye fluke - Diplostomum spathaceum - for most of the fish had opaque eye lenses. On the contrary the Brown trout - Salmo trutta seemed to show resistance to this parasite. These observations were noted in the earlier studies made of these ponds. Further investigation of the stomach content of these rainbow trout in the laboratory revealed presence of Limnaea pereger. These are the intermediate hosts of these parasites. Again it has been observed that black headed gull used to frequent these ponds, to feed on the trout. In so doing they help to spread the parasite among the ponds for they (the gulls) serve as the final host. But why it is that only the rainbow trout are most susceptible is a question that isn't easy to answer. This susceptibility however has been attributed to the fact that the rainbow trout is an alien spp. and perhaps have not developed the immunity against this parasite, which the Brown trout - the indigènous spp. might probably have.

Trip 3

Studies of: Loch Fyne, Rivers Fyne & Kinglas in Argyll & Inverary Trout farms for Improvement facilities 20-11-75

Rivers Fyne and Kinglas are known spawning rivers for salmon and sea trout. The River Fyne provides the water for the hydroelectric power station there and to avoid danger to salmon and trout a fish-screen is built to keep off the fish from the region of the turbines. Because of this scheme, the flow regime of the river was changed thus resulting in a reduced average daily flow (a.d.f). To make up for this reduction, water discharged from Allt na Lairige power station now supplements the River Fyne water. Also a lot of river improvement scheme has been carried out in River Fyne by use of weirs-gabions to help in pool and rapid formations. These aspects of river improvement will better the spawning ground for salmon. By pool formation, invertebrate fauna are helped to be built up. The larvae of stone-flies, midges and other chironomids can effectively be anchored on the boulders. The rapids provide effective aeration of the water and the riffles formed are good spawning places for salmon. The River Kinglas does not offer as much fishing for anglers as the River Fyne, because of its heavily wooded banks which give restricted access. During flood conditions however, limited fishing takes place in River Kinglas. There is a salmon netting station in Loch Fyne which is fed by River Fyne.

Records of catches in River Fyne between 1961-1967 have been so good and high. But most of these were grilse returning to spawn. By 1968 to 1974 there was a fall in catches and this could be attributed to fish mortality and perhaps overfishing in the previous years. This drop could not be attributed to U.D.N. (ulcerative dermal necrosis) disease. Though U.D.N. broke out in 1967, there was no case of this in River Fyne, until 1974.

To save the declining situation in the angling catches and for the overall improvement of the rivers, these positive approaches have been suggested.

(i) In River Kinglas, there is need for opening up more and better access road and stock supplementing through artificial propagation.

(ii) In River Fyne, there is need for more weir construction for pool formations and possibly easing of falls for ascent of salmon. But where this is not possible, there may be strong need for artificial propagation through planting of eyed ova.

Generally there may be need to regulate the indiscriminate angling going on and need to collect information on catches so as to assess any successes achieved through these improvements.

Inverary Trout Farm: The Inverary Fishfarm is capable of disposing for sale a total of about 80,000 rainbow trout in each season. This farm is purely a rainbow trout fishfarm and private. It has a simple design with the ponds running parallel. There are well over twelve ponds and each group of ponds is designated for a particular age group. There is also a hatchery to the farm and fertilized eggs are either bought for the hatchery or stripped from brood stocks each season. No case of outbreak of disease reported yet and the incidence of eye fluke attack is very insignificant.

Two large ponds are open to the public for fishing and rods are hired out to anglers. The public is allowed to buy food to feed the young fish in the ponds. It is virtually a good tourist attraction and thus a means of additional revenue.

Trip 4

Catching and Stripping of Salmon at Peebles - Scotland 6-12-75

The Glensax Burn (small river) is one of the Tweed tributaries used by salmon, Salmo salar and sea trout for spawning. Spawning runs start about mid autumn though the salmon start later than the sea-trout. Spawning takes place between October and January and even till February. On 6-12-75, a team which included some Scottish members of Institute of Fisheries Management led by my supervisor Dr. D.H. Mills, went to the Glensax Burn at Peebles to catch and strip salmon and sea trout. The essence of this exercise is to:

(i) participate in and have a good knowledge of stripping of fish for artificial propagation

(ii) realise the importance of stripping in stock supplementation

(iii) Learn how to carry out artificial fertilization and

(iv) have an idea of the working system of electric fishing equipment in the catching of fish.

A pulsed D.C. battery type equipment capable of producing 500 volts was used for the electrofishing of salmon and sea trout. Two electrodes - the cathode and the anode were connected to the equipment which was placed on the river bank. The cathode was left stationary in the water some distance from the anode. A stopnet was fixed across the river downstream to trap the floating stunned fish. The anode was moved about in the water while others followed with pick nets to collect the stunned and paralysed fish. When the equipment is working, direct current is sent out into the water. This direct current induces 'galvanotaxis' so that the fish move towards the anode. In intense electric field, the fish are stunned and their bodies completely relaxed and they tend to turn over. But they recover sooner when the current is switched off. There is also an A.C. equipment but this seems to have a stronger effect on fish for it can cause fracture of the spine in adult salmon. However the D.C. and A.C. equipments are used under different water conditions. The D.C. equipment is better in turbid and vegetatively populated waters for loss of fish is less incurred since the fish move towards the anode.

Both male and female salmon and sea trout that were ready for spawning were caught stripped and released. The stripping was gently done. A noose was put round the 'neck' of the female fish and held up with the tail pointing down. The fish was allowed to relax and with a very gentle rundown of the fingers on the ventral side, the eggs were shed into a collecting container (without water). A similar exercise was done on the male fish and the milt was shed to fertilize the ova. The sea trout was similarly treated but into a different container. The eggs were then washed off the excess milt several times and left in water for some 2-3 hours (delicate period) and eventually taken to the Department's hatchery for further development, leading to alevin and fry production.

Before we left the river, we went round to observe the redds (spawning nests) built by salmon and sea trout. About three redds could be detected. It is really funny the amount of work done by salmon during the spawning season. The artificially fertilized eggs put in the Departments hatchery, started hatching after 2 months i.e. in early February 1976. This has taken a long time because of the low temperature in the winter season. With an increase in temperature to about 10°C the incubation period may last between

30-40 days.

In conclusion I will like to add that precaution must be taken when electric fishing. It should be borne in mind that electric current is set up in the water and that the effectiveness of the current depends on the conductivity of the water. The higher the water conductivity due to dissolved salts and high temperature, the more contracted the electric field around the electrodes. Necessary insulators like rubber hand gloves, wading boots etc. should be worn by all active participants during electric fishing.

Trip 5

Field Work and Studies with the Severn Trent Water Authority, Nottingham 26-1-76

The Severn Trent Regional Water Authority is one of the ten regional water authorities in England and Wales. Following the Drainage of Trade Premises Act 1937 (which stipulated that industries are to discharge their effluents into sewers and the local authorities have the responsibility of purifying them) a Central Advisory Water Committee was set up. This Committee recommended the establishment of Rivers Boards for England and Wales, to take charge of prevention of pollution, fisheries administration (unlike the Scottish River Purification Boards) and land drainage. By 1948 River Board Act, 32 River Boards were established and these later took the name River Authorities as amended by Water Resources Act 1963. This Water Resources Act 1963 gave the River Authorities an additional function of water conservation. But by Water Act 1973, the River Authorities became Water Authorities and only ten Water Authorities were created for England and Wales, owing to this reorganisation.

The Severn Trent Water Authority is a merger (Severn and Trent River Areas). My visit was only confined to the Trent River Division which has its main technical office in Nottingham. The Fishery section has its own staff. The Area Fishery Officer is Mr. R. Templeton and Dr. Alan Starkie is the Fishery Biologist. The northern part of the Trent River is covered by one Fishery Officer and so too for the south. Each Fishery Officer has some river inspectors (not the type obtained in Scottish River Purification Boards) under him. The duty of these river inspectors is to carry out checks on the rivers to ensure that no illegal method of fishing is taking place and that no pollutant of any sort is being discharged into the water. In fact they function as the river custodians and can under statutory law prosecute offenders. A recreation officer whose duty it is to see to the interest of anglers is attached to S/Trent Water Authority as well.

Like the River Purification Board in Scotland, the S/Trent Water Authority has Chemistry & Biology sections. The biology also deals with fish diseases for there is a trained staff for this. Fisheries interest is glaringly covered while in Scotland it is superficially treated. The chemistry is adequately equipped for the different analyses as done by River Boards. During one week stay in Nottingham, I worked in the field with the fisheries team under the Fishery Biologist.

<u>27-1-76</u>

On this date we went to Stone from Nottingham to carry out fish population survey exercise on the Trent Mersey Canal. This is a coarse fish canal. It was stocked with coarse fish by Feyton Angling Club but the club has not in any way obtained any benefit from the stocking. So a formal approach was made to the Severn Trent Water Authority to find out if any fish still remained in the canal and the possible reasons for the very poor returns. Unfortunately no record was kept of the stocking and the S.Trent Water Authority was not informed before the stocking. In fact the angling clubs have never in the past consulted the Water Authorities before any stocking. They just take the initiative and only to run back to the Water Authorities for help when they are running into trouble. However the Water Authorities are making efforts to put a stop to this practice so that the fisheries will be better managed.

For the survey exercise, an A.C. electrofishing equipment with electric shockers mounted on the bow of a boat was decided to be used. Unfortunately as an attempt was made to start the generator, the shafts got broken so we had to discard the A.C. equipment. The pulse D.C. equipment was then used. This equipment was carried in the boat as fishing was going on. The fishes caught were mostly Bream, Chub and Roach. They were marked with jet innoculator and alcian blue, measured, examined and released. The essence of examining them was to find out if disease and parasite, were responsible through mortality, for the poor catch. The canal has upper and lower reaches and both were fished once properly.

<u>28-1-76</u> :

The Fishery Biologist, the technician attached to the Fisheries Section and myself, travelled to Calverton from Nottingham. At Calverton, the Severn Trent Water Authority runs a coarse fish farm which consists of small ponds. It is however envisaged that some of the ponds will be integrated in future to make them bigger. The fish mostly cultured here are the carp (common, mirror and crucian) and trout. Others are rudd, roach, tench and insignificant quantity of goldfish. The exercise done here was complete netting of a pond to take census of the stock. The other ponds would undergo the same process. The intention of this was to have a good knowledge of the quantity of fish in the farm, for such a record has not been kept. The pond we netted had a good stock of carp (832 for common, mirror and crucian, combined). Other spp. of fish (rudd, roach) netted out made up the number of fishes to eight hundred and fifty one (851). All the fish were measured and scales taken for age determination and were eventually returned to the pond. This farm has a hatchery attached to it. From here fingerlings are supplied to the ponds for further rearing. The farm is under the supervision of a farm manager. Plates 7 and 8 show parts of the hatchery and the fishfarm respectively.

<u>29-1-76</u>

Our team as on 28/1/76 together with two river inspectors set out for River Sence near Tamworth, for another population survey exercise. Another angling club complained to the Severn Trent Water Authority that River Sense has failed to satisfy her members since it was polluted in summer of 1975. The purpose of the population survey was therefore to ascertain if scarcity of fish in the river was as a result of mortality from the pollution. The result of this exercise will help the angling club in making claims, from the individuals responsible for the pollution, for the damage done to the river. As usual, a pulse D.C. electrofishing equipment was used for this job. Throughout the fishing period, only four small and sick looking rainbow trout of average length of 5 cm were caught. I wasn't however given details of the nature of pollution so I can't say anything about it.

<u>30-1-76</u>

We made another visit to the Severn Trent Water Authority coarse fish farm at Calverton to continue with the exercise of 28/1/76.

My one week stay in Nottingham and active participation in Severn Trent Water Authority Fisheries functions effectively exposed me to some field experience in some aspects of management technique. However the period of these exercises was marked with very unfriendly weather for it was freezingly cold and temperatures ranged between $3^{o}C$ to $-2^{o}C$.

Trip 6

Field work and studies with Yorkshire Water Authority - Leeds 14-6-76

The Yorkshire Water Authority is one of the ten Regional Water Authorities in England and Wales. It has the same functions - water conservation, fisheries administration, land drainage, pollution control etc. like other regional water authorities of England and Wales. The present Water Authorities were formerly River Authorities by Water Resources Act 1963. But by the Water Act 1973, the River Authorities became Regional Water Authorities with additional duties of water conservation, Fisheries administration and land drainage. Also by the Water Act 1973, the number of the Water Authorities was reduced to ten due to reorganisation, which took place as from April 1974.

A couple of days were spent in the area of the Yorkshire Water Authority during which some of the divisions of the Y.W.A. were visited. The Authority is composed of a chairman and twenty-four members. Eleven of the members were nominated by government ministers and the others came from local authorities in Yorkshire. Dr. John Shillcock is the Amenity Fisheries and Recreation Officer for Yorkshire Water Authority (Y.W.A.) and is based at the head office in Leeds. The approximate size of the Authority's area is about 6,000 sq. miles. The Yorkshire Water Authority's essential duty is to care for the well-being of the rivers of Yorkshire for their use. To this end, they build, maintain and operate engineering works to supply and recover water, control flows into sewers thus controlling and preventing pollution, alleviate floodings through drainage schemes, control abstractions from and discharges into rivers and operate compensation water through numerous reservoirs. They also manage water quality, conserve and develop fisheries and amenities, encourage angling and water recreation in the rivers and reservoirs. The Y.W.A. has a large staff for the above-mentioned schemes. It is estimated that almost 6,000 people are in the employment of Y.W.A. Mr. S. Bailey is the Fisheries Officer in the Fisheries section of the water authority. There are other Fisheries Scientists also for fish population and disease studies. The Y.W.A. employs eight Fisheries Inspectors for the protection of Fisheries within its area and for the enforcement of the Salmon and Freshwater Fisheries Acts and Fisheries byelaws. Other works include fish rescue and transfer, scientific work on growth rate, movement of fish and deliveries from the Authority's trout hatchery at Pickering. There are about 260 Angling Clubs and Associations registered in the Authority's areas. It is however estimated that many existing clubs are unregistered.

Attempt to combat river pollution has been followed up by the establishment of sewage treatment works. Currently Y.W.A. has over 500 sewage and effluent treatment works and these are estimated to handle about 240,000,000 gals. of domestic and industrial wastes per day. Despite this effort some of the rivers in Y.W.A. area are still highly polluted. Rivers Aire and Calder are affected by pollution but Rivers Don and Rother are the worst polluted in Yorkshire. A good number of the rivers and reservoirs of Y.W.A. were visited in the company of its Fisheries staff (Dr. J. Shillcock, Fisheries & Amenity Officer, Mr. Stephen, Bailey-Fisheries Officer; and Mr. John Hick, Officer-in-charge of Fishing licence).

River Wharfe at Tadcaster near York

This river drains one twentieth of the area of Yorkshire and supplies the majority of the water for Leeds. The headwaters of this river rise in the Craven District of the Pennines, an area which is predominantly formed of carboniferous rocks. River Washburn, a tributary of River Wharfe provides water to Leeds and its suburbs from its series of reservoirs - Thruscross, Fewston and Swinsty. The Grimwith Reservoir which is formed from one of the tributaries of the River Wharfe is planned to be expanded so as to serve Bradford and Skipton areas by increasing the flow in the river to permit additional abstraction lower down River Wharfe. Considerable work on improving the flood control basins has been done through land drainage schemes. River Wharfe has partly been affected by sewage and industrial effluent which has caused the partial disappearance of trout within Tadcaster area. The industrial effluent is from the nearby brewery. High fish mortality has often occurred in summer due to combined effects of low volume of water, presence of pollutants and highly reduced O_2 level because of the high B.O.D. resulting. During high flows about 5000 m.g.d. are recorded. Effective dredging and widening of the river at Tadcaster has been in operation and, because of this, changes in the ecology of the river have taken place. Weed problem has been partially solved. Changes in habitat gave rise to invasion by coarse fish. At present some of the coarse fish existing in this area are the roach, rudd, pike and perch. However on other areas of the River Wharfe, trout, grayling, chub, dace, eels are present. Presently Tadcaster Angling Club seems to have absolute fishing monopoly on this river at Tadcaster. The fishing method is not restricted to fly fishing. Maggot and worms as baits are allowed.

Fishing Licences are generally required before any fishing is permitted on any of the waters and these licences are issued by the Amenity, Fisheries and Recreation Department of Y.W.A. Leeds.

River Ouse (York)

The part of this river in York was visited. This river is tidal. It is a coarse fish river and it is known to harbour more roach and bream than any other coarse fish. It was once a salmon river but owing to industrial pollution the river is no longer safe for migratory salmonids. The River Ouse is a continuation of River Ure starting from some eleven miles above York. The overall picture of this river shows a mixture of advance and retreat in Fisheries condition. Meanwhile a smolt tagging exercise is carried on the River Ure at Mickley by Y.W.A. The tagged smolts are transported and released at Brough Haven where they have access to the sea. This is an attempt to reintroduce salmon into the River Ouse on the knowledge that adult salmonids return to the parent river to spawn. A smolt trap is set on a mill race at Mickley near Ripon to trap the sea going smolts. The return of two of the smolts, transported from the River Ure, as adults to that river gives an indication of the success recorded so far by Y.W.A. in the reintroduction exercise. Table 2 below gives detail of the progress made in the reintroduction experiment.

Table 2 : Details of Stocking Rates, smolts trapped and recaptures in the Reintroduction of Salmon experiment, into River Ouse.

(By courtesy of Y.W.A. Leeds,1975)

Year	Total Nos. of Fry stocked	No. of smolts trapped	No. of smolts tagged	Recaptives	% Recaptured
1965	57,000				
1966	150,000				
1967	201,000	500	500	Numerous unrecorded recaptures chiefly from Greenland	
1968	289,000	819	689		
1969	200,000	1890	1248		
1970	190,000	4200	3980	38 total. 2 River Ure 19 Greenland, 3 Humber 1 Trent, 1 Cumberland 7 Northumberland 3 Scotland, 2 Yorkshire	0.95
1971	200,000	969	969	7 total. 2 Greenland 2 Scotland, 1 Cumberland 1 Northumberland, 1 Yorkshire	0.70

River Esk at Whitby

The River Esk which is a popular salmon river in Yorkshire runs out to the sea through Whitby. An electronic fish counter is fitted in the fish pass at Ruswarp on the Whitby Esk. This counter takes a population census of the stock during salmon runs. River Esk and the tributaries have a catchment area of 139.9 sq. miles and from the pollution survey results conducted in 1973, it is regarded as a class I river. Water is abstracted for domestic supply by Scarborough Corporation Water Department at the tidal limit at Ruswarp.

Along the coast at Whitby, Scarborough, Bridlington and further south, commercial salmon netsmen set their nets (bag nets and stake nets) to capture salmon returning to spawn. Altogether the Yorkshire Water Authority has on record a total number of twenty-nine nets on the coast. The results of salmon and grilse catches per net examined in relation to Whitby alone from 1965 - 1972 reveal a decline in 1966, 1968 and 1972. It is expected that grilse catch should improve in 1973 due to the Net Limitation Order which restricts the great increase in netting effort and cut the number of nets back to 1968/69 level.

Trout farm at Pickering

The farm belongs to the Y.W.A. It has two large ponds capable of accommodating 33,000 trout, 20 growing ponds each containing 3000 trout 9" - 11" and 12 yearling ponds each containing 10,000 of 6" - 8". About 350,000 brown trout eggs are hatched every year according to the farm manager - Mr. M. Lawson. Out of about 20 hatcheries in Yorkshire, only one - the Costa Hatchery at Pickering farm belongs to the government. The rest are privately owned. Fry tanks about 24, each containing

10,000 fry are used for the alevins fresh from the hatchery. They stay in these tanks for 4-5 months and are taken out into the rearing ponds by May/June. Plates 9 and 10 show parts of Y.W.A. farm at Pickering.

The Y.W.A. trout hatchery has produced more fish than usual in 1973. 77,000 brown trout plus 10,000 fry were sent out including 9,200 as free grants. Fish are sold within the Authority's area and the distribution is as shown, to the river catchment areas. Table 3.

Aire	Calder	Derwent	Don	Esk
10,200	3,005	8,250	9,155	500
Hull	Nidd	Swale	Wharfe	Yore and Ouse
2,800	5,700	6,120	19,210	12,900

Table 3: Distribution of Fish to River Catchment areas in Y.W.A.

The Costa hatchery is also used for salmon eggs bought from Kyle of Suntherland. These salmon fry are the ones used for the reintroduction experiment in River Ure. Weed problem in the ponds is combated by cutting.

15-6-76 : Scarcroft

This is where the Y.W.A. has her fisheries depot for vehicles, tanks with O_2 supply device, nets and other fisheries equipments. Scarcroft which is near Leeds is provided with 3 ponds which are used for holding coarse fish between their capture and restocking time.

RESERVOIRS:-

Four reservoirs (Thruscross, Fewston, Swinsty and Lindley) were visited in the company of Dr. J. Shillcock - The Amenity, Fisheries and Recreation Officer.

Thruscross, Fewston and Swinsty Reservoirs

These reservoirs are connected, the flow being from Thruscross to Fewston and Swinsty. Because of the geomorphological nature of the Thruscross, the water is peat and tend to be more acidic than those of Fewston and Swinsty. All these reservoirs are stocked with 5" rainbow trout and during the fishing season, anglers take licence for fishing. Because of the water quality of Thruscross reservoir, mainly trout is supported here. The other two reservoirs support both trout and coarse fish. Thruscross supplies domestic water to Leeds and compensation water released daily is about 2 million gallons. The Swinsty at the time of visit was greatly reduced in level. See attached Plate 4 . This drought condition as expected might be a result of the highly prolonged hot weather and less rain for a good period of time. All these reservoirs have their fishing regulations as to the size of fish to be taken out, when to fish, method of fishing, interference with any of the reservoir devices and other uses of the reservoirs not permitted by Y.W.A. All these regulations were laid down by the Y.W.A. to protect the anglers, waters and their public users and the fish stock at large. Daily fishing permits are given on payment of charges (40 p. for Fewston and Swinsty, £1 for Thruscross).

Lindley Wood Reservoir:-

This is a trout reservoir. Though built by Y.W.A. it is privately managed for the reservoir site is a private estate. This is purely a compensation reservoir. The management which falls on this private land involves issue of licence, purchase of and stocking with trout and other management techniques. Unlike the Thruscross, this Lindley wood reservoir does not provide for yachting.

Other Reservoirs:- (Thrybergh, Morehall, Underbank and Damflask)

These reservoirs are located in the Southern Division of Y.W.A. The Thrybergh reservoir though belongs to the Y.W.A., was given out to an Angling Club to administer and all matters relating to fisheries are referred to this Angling Club. It is a trout reservoir managed on 'put and take' basis. The Damflask reservoir in Bradfield near Sheffield supplies water to Sheffield and some of her industries. It also provides for yachting and other recreations. The reservoir is for both trout and coarse fishing. The trout fishing starts on 1st April - 30th September and the coarse fishing starts on 1st June - 31st January.

The Morehall and the Underbank reservoirs equally offer recreation to anglers. Morehall is mainly trout reservoir while the Underbank like the Damflask is for mixed fishing. Underbank supplies water to Stockbridge. When full it has a mean depth of 53' and releases 30 million gallons of compensation water weekly. As mentioned before all these reservoirs have their respective fishing regulations. Though the regulations are similar, the fishing times and daily charge for tickets differ. This is however dependent on the type of fishing offered by the reservoir. Size limits of fish to be taken out are equally stipulated for the salmonids and the coarse fish. Bag limit allows only six fish in one day.

Nostell Priory Lakes (South of Wakefield)

These three lakes at Nostell are owned by the National Trust. The top lake (26 acres) is known for the large stocks of tench, roach, rudd, bream, pike and carp (common) it contained. It is the most polluted lake of the three since it is nearest to the mining works.

The middle lake (about 7 acres) is well stocked with tench, bream and roach and with some trout. It is partially a mixed stock though the coarse fish is more dominant.

The bottom lake (4½ acres) is mainly a trout lake. It has the cleanest water of the three lakes. All these lakes except the last, are self sustaining. The trout lake is restocked with brown trout from the Y.W.A. Costa fish farm at Pickering. These restocks replenish what is removed from the lake by anglers. This trout lake is run on 'put and take' basis. Licences are required for fishing in these three lakes and the proceeds from the sale of licences go to the National Trust.

Trip 7

North of Scotland Hydroelectric Dam & Freshwater Fisheries Lab. Pitlochry - Scotland

24-11-75

The North of Scotland Hydroelectric Board has a hydroelectric power station situated on the River Tummel in Pitlochry. This power station has a dam across the River Tummel. Here I met Mr. Mills who took me to all the mechanical and electrical sections of this hydro-electric dam. River Tummel has for long been associated with salmon and trout that go upstream for spawning. Because of the dam, an obstruction has been created in the way of the upstream migrating salmon and grilse and also downstream returning kelts and smolts.

The Hydroelectric Development (Scotland) Act 1943 makes it a duty of the Electricity Boards to "have regard to the desirability...... of avoiding as far as possible, injury to fisheries and to the stock of fish in any waters". To this end therefore a fish pass (ladder) has been incorporated into the dam. A hatchery which is capable of handling 1,250,000 salmon eggs has also been built inside the dam. With the fishladder and the hatchery (though not belonging to Board of N. Scotland Hydroelectric Scheme but the Tay Salmon District Fishery Board), losses in stock and recruitment have been reduced to the barest minimum. In the display room of this Hydroelectric Scheme, the operational system of this scheme together with that of Borland's Fishlift System, are electronically displayed. In the observation room in the dam, fish movement can be seen through the observation window. There is a fish counter (an electronic equipment) which takes census of all upstream going salmon for spawning and the returning kelts. The figures so collected will help to build up the statistics of fish movement before and after spawning. The figures will also serve a comparative purpose to determine whether there are increases or losses and then decide on necessary steps for improvement. Of necessity there is a gauze screen on the downstream side of the dam. This fish screen keeps off the upstream moving salmon from getting into the turbines. The drumgates which operate the movement of water into the turbines are all automatically controlled.

Freshwater Fisheries Laboratory (Officer-in-charge:- Mr. A.V. Holden)

This freshwater fisheries laboratory belongs to the Department of Agriculture & Fisheries for Scotland. I was met on arrival by Mr. R.B. Williamson who introduced me to heads of different sections - Chemistry, Fisheries Management, Parasitology etc. Incidentally Mr. R. B. Williamson has worked in Malawi for years as the Chief Fisheries Officer and was in the appraisal team that visited Nigeria for the survey of the Lower Niger Basin in 1973. He visited the Ogba Fishfarm in Benin-City, Nigeria.

A lot of highly stimulating work is being done in this laboratory and the research so far carried out has been of use in the overall management of salmon and trout stock - both adult and juvenile. The Chemistry section carries out a lot of water analysis and detection of presence of pollutants and contaminants such as heavy metals and other metals and compounds in substances - both organic and inorganic samples. This complex work is simplified by use of autoanalysers, gas-liquid chromatography and atomic absorption spectrophotometry. The Parasitology & Fisheries management sections use Loch Leven as one of their research fields. They were connected with the I.B.P. (International Biological Programme) project at Loch Leven, Kinross.

Trip 8

Loch Leven in Kinross - Scotland 1-12-75

This was a team visit under my academic supervisor - Dr. D.H. Mills, to Loch Leven. On arrival we were met by Mr. J.E. Thorpe of Freshwater Fisheries Laboratory in Pitlochry. He has worked intensively with other researchers on the survival rates of trout in the loch and other factors influencing the life of trout (both adult and juvenile) in the loch. We had a little academic chat before going round to have a look at the loch. Unfortunately the weather was bad for it snowed all through the period of the visit so we couldn't see much.

Loch Leven is particularly peculiar for its productivity. It lies on a fertile plain of Kinross where the soil is derived from old red sandstone and carboniferous rocks. It was formed at the end of the last glaciation from kettle holes left in glacial drifts by retreating ice. The loch is fed by four rivers and the only outflow is the River Leven. The South Queich is an excellent spawning ground for Brown Trout of which many are supported by Loch Leven. The catchment area extends to about 145 sq. kilometers and 70% of this, is rich in agricultural land. The mean depth is about 4 meters and the water level is controlled by sluice gates. The loch is continuously being enriched by the flushing-in, from the feeder streams of agricultural wastes. Also phosphate increase in the loch is as a result of the Kinross & Milnathort sewage discharge and effluent from a woollen mill.

Thus, this loch has become so eutrophic and many aquatic flora and fauna supported. The fish spp. found here include <u>Salmo</u> <u>trutta</u> (Brown

Trout), Perca fluviatilis (Perch), Esox lucius (Pike); and Gasterosteus aculeatus (Stickleback). Loch Leven is popularly known for its brown trout angling which was made famous when the net fishing was completely stopped in 1873. Today many anglers and holiday people spend hours and days angling on the loch. In the early 20th century there have been significant variabilities in the ecosystem of Loch Leven. Fluctuations have also occured in brown trout populations. The possible causes ofinstability of both the quality and quantity of life in the loch might be the high nutrients. This might have led to high phytoplankton densities and further ecological succession which greatly influenced animal life. Again it might be due to the shallowness of the loch which has made the light condition to remain relatively good and so excess production of phytoplankton and invertebrate fauna, which eventually affect fish stock at the top of the food chain.

Trip 9

Forth River Purification Board -Edinburgh 20-1-76

The Forth River Purification Board is one of the eight River Purification Boards set up in Scotland. The others are the Tweed, Grampian (includes Moray, Nairn and Spey), Solway, Highland, Clyde (includes Ayr P. Bd., Argyll), Tay (now includes North and South Esk in Angus), and North East (includes the Dee and Don and Ythan). Each Board is headed by a Deputy Chief Technical Officer - River Inspector. Mr. Collet is in-charge of Forth River Purification Board. The River Purification Board peculiar to Scotland only was set up under the Rivers (Prevention of Pollution) (Scotland) Act 1951. By this Act, Central Authority is laid on the Secretary of State who has the duty of promoting the cleanliness of rivers, inland and tidal waters of Scotland. The Secretary of State appointed the Scottish River Purification Advisory Committee (S.R.P.A.C.) who in turn recommended the setting up of River Purification Boards to take charge of different areas of Scotland. The River Inspectors for the boards have the approval of the Secretary of State.

The River Purification Boards (R.P.B.) are charged with the statutory function of pollution prevention in Rivers as the title of the Act suggests. They do this by adopting a procedure under which no person should discharge effluent to a stream without the prior consent of the appropriate board. The consent can be refused though not usual. However the applicant must be strictly required to comply with the enforced conditions related to the self purification capacity of the stream. This Act, 1951, further empowered the R.P.B. to inform the Secretary of State of any water abstractions, volume of water removed from the stream, discharge and type of effluent by any person into a body of water. The boards have the right too to obtain and take away effluents or samples of water from any stream for analysis and legal proceedings. By Rivers (Prevention of Pollution) (Scotland) Act 1965,wider powers were given to the boards to cover existing and new discharges to rivers and certain areas of tidal water. Further it became compulsory that all written applications for any discharge of effluent apart from the ones specified in the Act 1951, to a stream should state the following:

(a) Nature and composition of effluent for which application is being made
(b) Maximum temperature of the effluent at the time it is to be discharged
(c) Maximum volume of effluent to be discharged on any one day and
(d) Highest rate the discharge is proposed.

The boards can make bye-laws as may appear expedient to them. Surprisingly these Acts (1951 and 1965) have given the boards no fisheries and land drainage functions in Scotland. So they exercise no pronounced control over the Fisheries. Their main function is to control and prevent pollution of the rivers and other waters as mentioned. However it will be ridiculous to talk of river pollution prevention in isolation without mention to life particularly fish, in the river. The result of their function therefore reflects on the general fish stock situation, within their areas of operation.

The boards are established in accordance to the existing local authorities. The members of the boards represent specific interests such as agriculture, industry, fisheries or other interests as appropriate in the area. The boards are financed by respective local authorities.

The Forth River Purification Board like other Purification Boards has its own range of specialist staff, to carry out its functions and facilities for investigation of all aspects of water cycle. There are six rivers in the area of F.R.P. Bd. - Forth River Purification Board.

(1) River Almond. It rises from peat mosses in North of Shotts in Lanarkshire. This river is polluted from bings drainage in former colliery workings. Because of this, the river has a high acidity with varying concentrations of iron. The influence of How Burn and Whitburn sewage works has caused low dissolved oxygen and high ammonia concentration about 15.5 mg/lit. Because of this condition the Brown Trout which the river is used to supporting, disappeared.

(2) Water of Leith. Has very little pollution. The Harperrigg Reservation influences the flow of this water which rises from the Pentland Hills.

(3) River North Esk. Because of the pollution by Valleyfield papermill now closed & further deterioration due to the volumes of ferruginous mine water discharge at Elginhaugh, samples show low biotic indices. This section is almost completely devoid of aquatic life.

(4) River South Esk. Has high water quality and maintains good sport fishery except between Newbattle and Dalkeith where toxic polluting discharge exists. Origin of discharge unknown.

(5) River Esk. Poor condition. Its quality dictated by River N. Esk. Fish survey result was negative.

(6) River Tyne. It rises from S.E. of Gorebridge and receives some iron-bearing water there from. It also received some water from Ormiston sewage works through not much long lasting harmful effect. Because of the added discharge from Haddington sewage works a low dissolved oxygen saturation was recorded.

The Forth River Purification Board has different sections under specialist personnels.

Biology Section:- Mr. D.J. Lawson is in-charge

This section carries out biological analysis and tests of the rivers to determine their biotic indices. This is a biological measure used in determining water quality. This biotic index system of test involves biological grouping of invertebrate fauna according to their affinity to different levels of pollution. The biotic index has a value 1 to 10 and this system is also utilised by the Severn Trent Water Authority. The biological surveys carried out are on macro and microbiological samples. Also protozoan and bacteriological surveys are done. The results of these surveys reflect on the fish stock situation.

Chemistry:- Mr. T. Williamson

The laboratory is well equipped with auto-analizers, atomic absorption spectrophotometry, gas liquid chromatography etc. for quick and accurate water analysis and detection of pollutants.

Hydrology Section:- Mr. G.S. Hamilton is in-charge

Section charged with the duty of recording the flow regime of rivers and monthly irrigation requirements. It has a number of gauging stations where mean annual river flow details are built up.

Trip 10

Oceanographic Laboratory - Edinburgh 20-2-76

The main objective of this laboratory is to investigate, study in detail and analyse the variability in the distribution of plankton in the North Sea and North Atlantic. Plankton as we know, is a general term used to describe all living things (plants and animals) that drift passively (in response to the currents of the sea). This laboratory has three mean teams - Instrumentation, Biology and Weather. All the results got from these teams are processed and analysed in the Data Processing Section. Mr. G.A. Robinson is the Officer-in-charge of the Oceanographic Laboratory - Edinburgh.

Instrumentation Team:- Dr. J. Aiken is the Officer-in-charge.

This section has a workshop where Continuous Plankton Recorder (C.P.R.) is produced. The C.P.R. is the instrument used for collecting and sampling plankton. The mechanism of this instrument is very intricate. With this instrument continuous sampling is carried out at frequent intervals over large areas. The C.P.R. is towed by merchant ships in the course of sampling operation. This equipment is the main gear of this laboratory, thus making it possible for the laboratory to carry out her three main aspects of work.

(1) Biogeography (purely analytical ecology) with special reference to studying patterns of abundance as well as ranges of distribution.
(2) Study intraspecific populations rather than spp. as the basic taxonomic units in ecological analysis.
(3) And analyse variation in abundance, distribution and

composition of plankton so as to relate it to physical environment.

The C.P.R. was designed by Sir A. Hardy in 1939. The body of the recorder is fitted with a towing eye, a diving plane, rudder and stabilisers (fins). See attached diagram of C.P.R. Figs. 1 and 2. As the C.P.R. is towed, its propeller operates an inside mechanism so that two rolls of silk each 6" wide are unwound from their spools at the rate of 4" of silk for every 10 miles of towing. For the purpose of analysis the silk bands are cut into lengths i.e. 4", corresponding to 10 miles of towing. The C.P.R. is towed at a speed of 12 to 19 knots, with 18 to 24 meters of wire, at a constant depth of 10 metres. Standard operational routes are as shown in Fig. 3 and in these routes about 60 C.P.R. are deployed.

There is another instrument - the Undulating Oceanographic Recorder (U.O.R.) which was recently invented and is under trial. This instrument combines plankton sampling and recording of physical variables in the euphotic zone at different depths. It can be programmed to undulate between a minimum depth of 8 meters and selected maximum depth between 15 and 70 meters, with an undulating length between 3 and 30 km. at any speed between 7 and 15 knots. (3.6 - 7.7 m/sec.). As it is towed it takes continuous series of plankton samples and records data on the magnetic tape from which salinity, depth and temperature can be derived with accuracy. This instrument is automatic, self contained and generates its own power supplies. See attached annex 1 with diagrams of the U.O.R. The sampling pattern and physical variable readings are shown. See same attached print (annex 1) from the Oceanographic Laboratory.

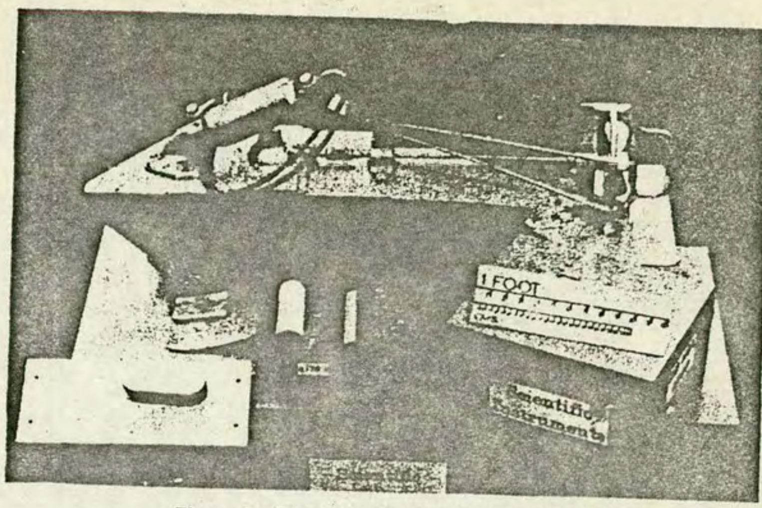

Figure 1. The Continuous Plankton Recorder.

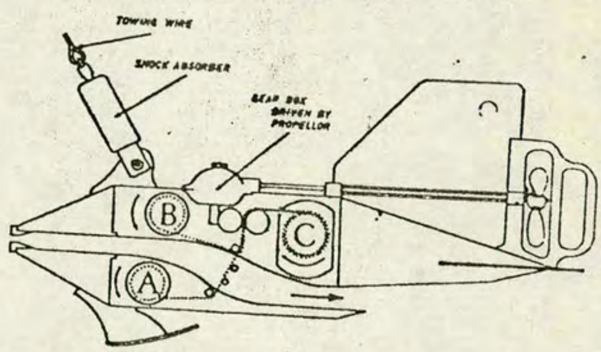

Figure 2. A diagrammatic longitudinal section of the Continuous Plankton Recorder.

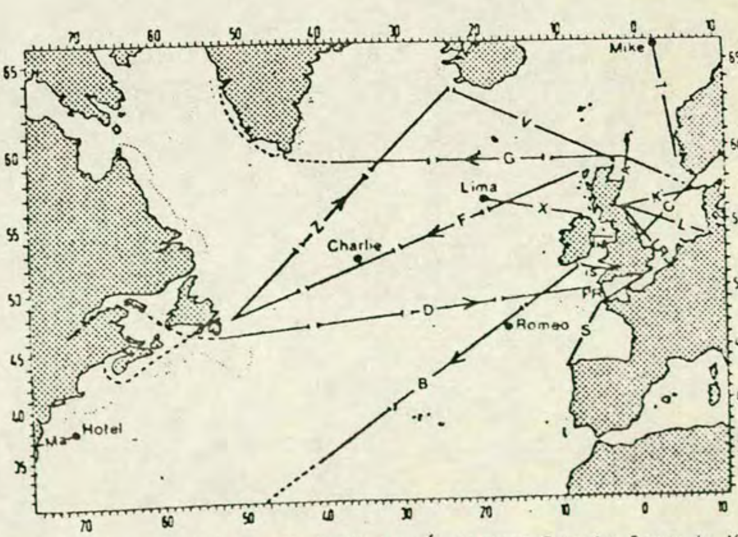

Figure 3. The standard routes of the Continuous Plankton Recorder Survey in 1975.

Biology team:- Dr. P.C. Reid is in charge.

Here the C.P.R. samples are analysed for phytoplankton and zooplankton in different ways.

(1) Colour: This is assessed into three categories of greeness against the standard colour chart and numerical values given to these colours categories based on acetone extracts. This system was devised by Mr. G.A. Robinson for phytoplankton.

(2) By counting of diatom and dinoflagellates spp. through diagonal examination of the 4" long filtering silk.

(3) Eye count for big zooplankton in particular from these monthly means of phytoplankton spp. distribution, are worked out for the six standard areas B_1, B_2, C_1, C_2, D_1 and D_2. See attached diagram Fig. 4
From the teams observation so far, since 1958 it is noted that phytoplankton colour has increased whereas the number of diatoms have declined drastically and Ceratium spp. have only undergone minor changes in number. It was speculated that pollution, climatic change, biological succession and phytoplankton composition must have caused the biological variability since 1958. However there is greater belief, based on their findings so far, that the main causative factor behind the variability of the North Sea phytoplankton is the northern hemisphere hydrometeorological trends. These appear to be related to an unexplained decline in the available solar energy. This has led to a change

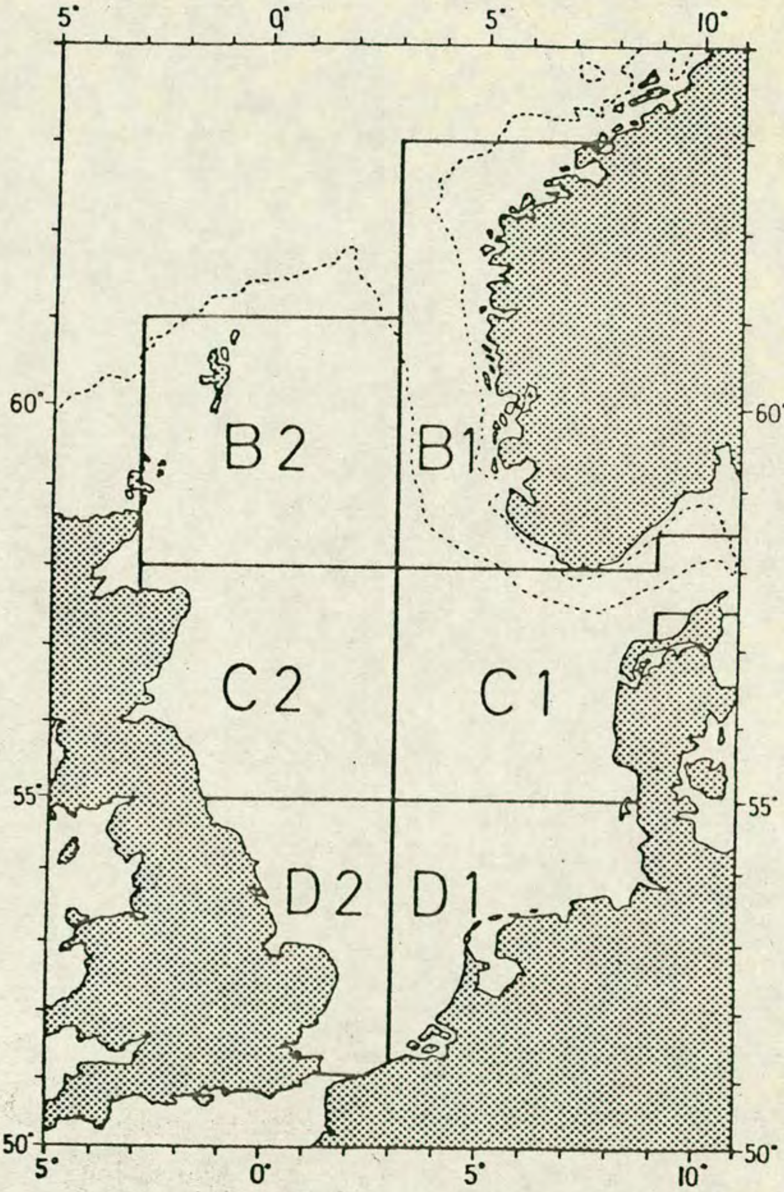

Figure 4 North Sea Standard Areas

in pressure belts and a southerly advance of the arctic ice which in turn has caused lower temperatures and changes in the water movement of the North Atlantic.

Weather Team:- Officer-in-charge - Mr. William.

He is a hydrometeorologist. The team has an observation post in North Atlantic. Team takes record of weather changes within the North Atlantic zone. Mr. William is currently working on a new system of plankton recording equipment called - Long Hoist Plankton Recorder - (L.H.P.R.). This is purely for zooplankton sampling. It is towed by a research or merchant vessel at a depth of 1000 meters and samples diagonally up to the surface as shown below. It is capable of taking 100 samples automatically at different depths and at the same time recording temperature, salinity and pressure at these different depths. The separate results of

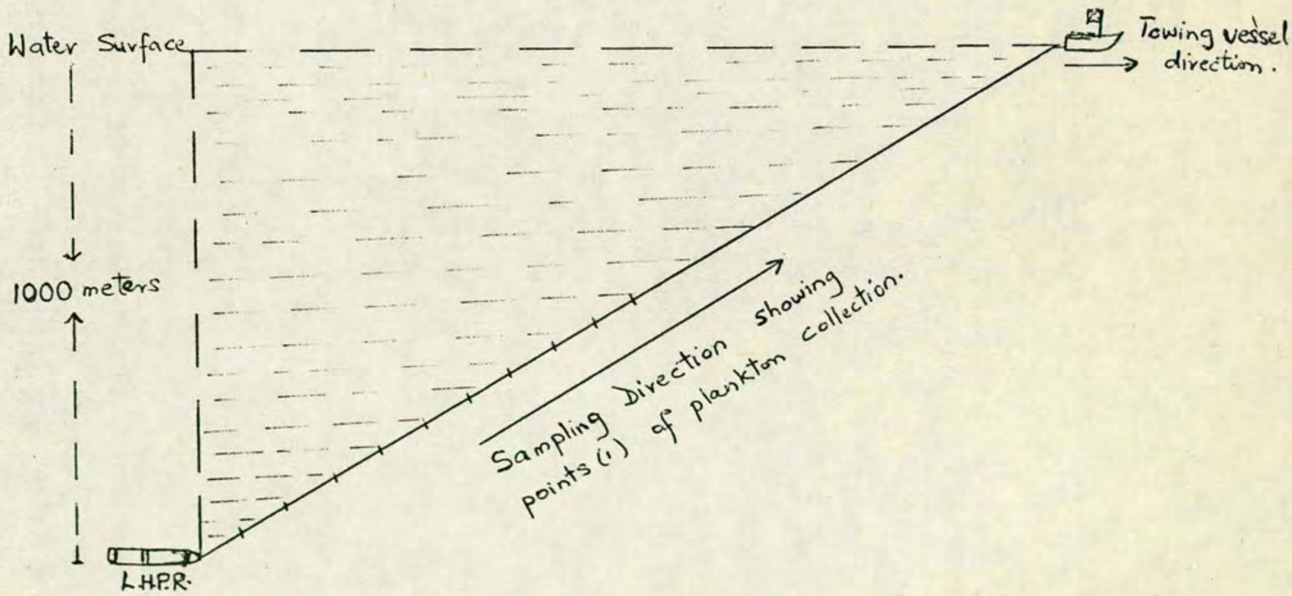

FIG. 5 : Zooplankton Sampling Method of Long Hoist Plankton Recorder

different sections are analysed and processed for a more definitive conclusion. So far the findings have not been unconnected with climatic conditions and the circulation system of North Atlantic. This study is continuous. The extensive and intensive research result will help tremendously in determining the fate of life and possible consequences to life (particular fisheries) by these changes in the plankton distribution and variabilities in the North Sea and North Atlantic. With the results from these research works, the Oceanographic Laboratory can act on advisory capacity to any government interested in the North Sea and North Atlantic Fisheries.

ANNEX 1

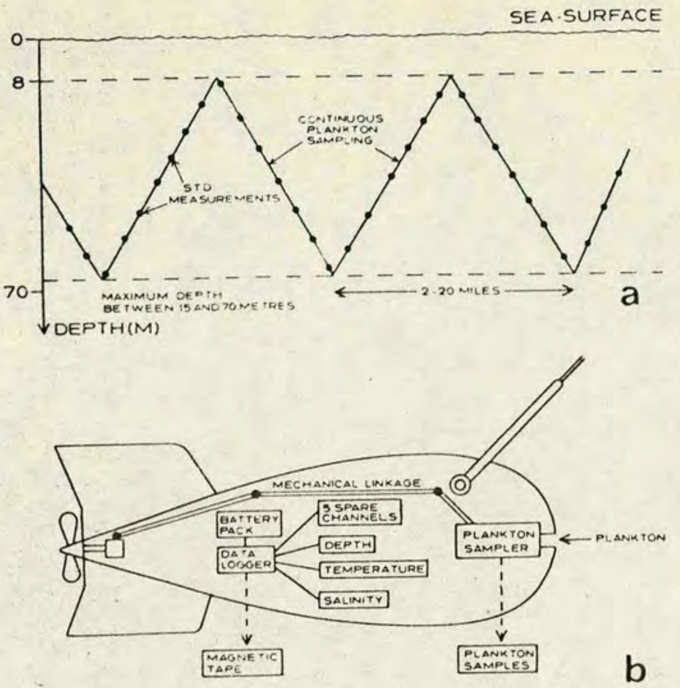

Fig. 1. (a) Diagram showing nominal undulation profile of UOR Mark I. The UOR can be programmed to perform regular "saw-tooth" undulations between 15 and 70 m; it samples plankton continuously and measures salinity, temperature and depth (STD) at pre-determined time intervals. (b) Block diagram showing instrumental payload of UOR Mark I.

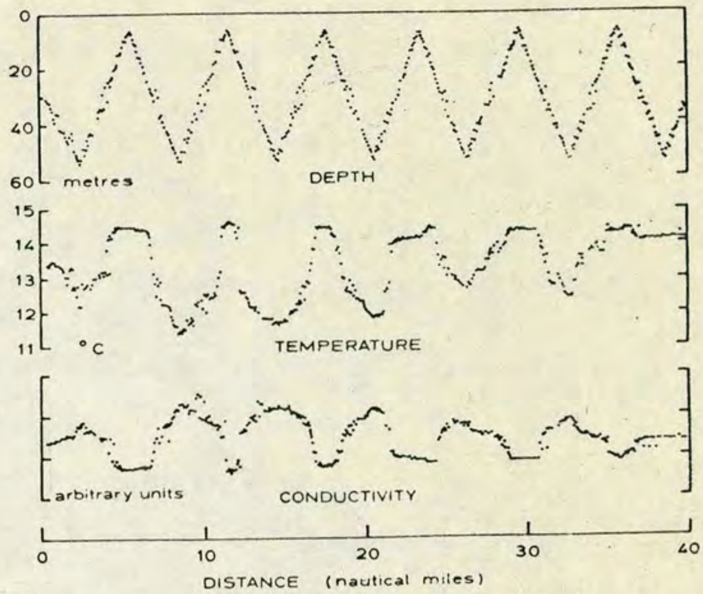

Fig. 3. Raw data taken by UOR Mark I during trials in Irish Sea, showing well-formed undulations between 6 and 55 m depths. Each dot represents separate measurement (at 25.6-sec intervals) of depth, temperature or conductivity. Small scatter of points near mid-depth corresponds to oscillations of up to ± 3 m amplitude about the chosen undulation profile. UOR was towed at 11 knots on 200 m of unfaired 8-mm diameter cable

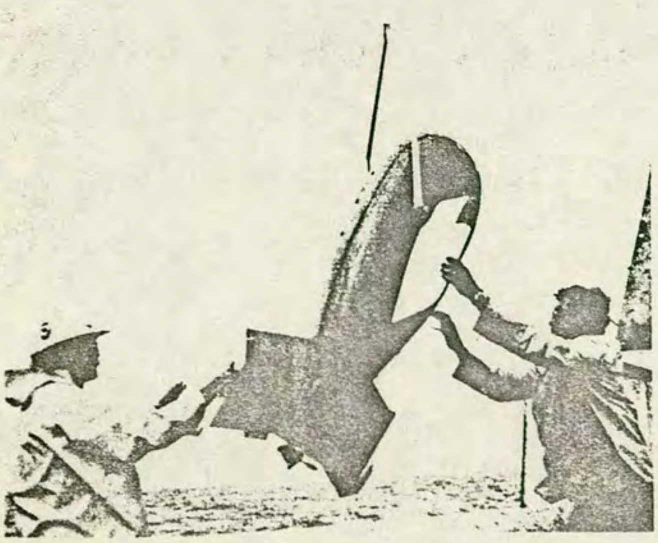

Fig. 2. UOR Mark I being recovered at end of tow

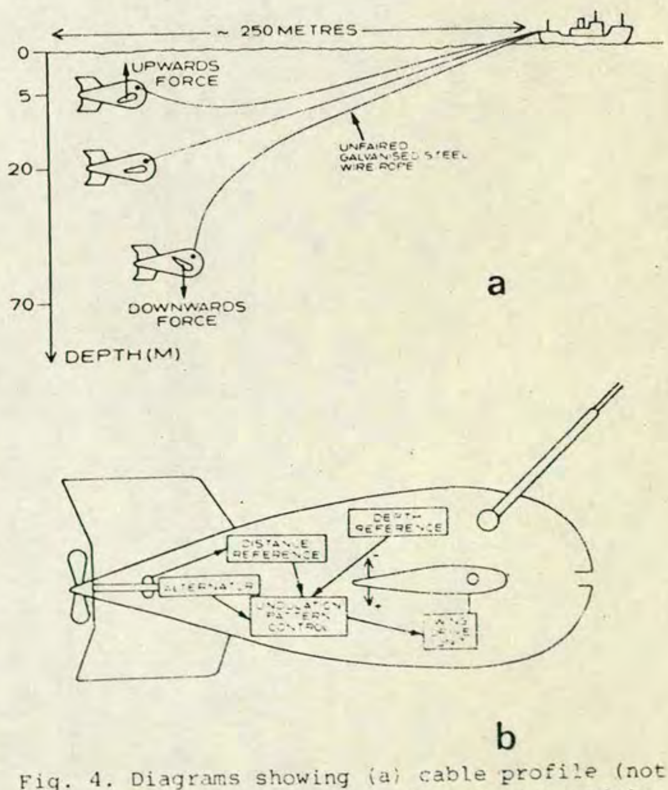

Fig. 4. Diagrams showing (a) cable profile (not to scale) and positions of wings during undulation cycle, (b) system for servo-control of wings

Trip 11

Marine Laboratory (Department of Agriculture & Fisheries for Scotland) - Torry - Aberdeen

17-3-76

The Marine Laboratory - Aberdeen was visited on 17/3/76. This is a laboratory of the Department of Agriculture & Fisheries for Scotland. It has a staff strength of about 200. Of this number about 160 members of staff are engaged in research work and the remainder form the administrative section. The research work in the laboratory embraces a wide range of problems concerning the marine fish and shellfish resources exploited by the British Fishing Fleets in near and middle distance waters. A number of research vessels are engaged in this work. These are:-

(1) Scotia (Fisheries Research Ship): Currently engaged in fish tagging work.

(2) Explorer: (Fisheries Research Ship - F.R.S.): formerly engaged in trawling surveys and fish tagging in the Northern North Sea, current meter laying and recovery, environmental work, herring larval surveys, fish behaviour studies and experimental trawling in gear testing.

(3) Clupea: (F.R.S.): Engaged in herring larval survey, pelagic trawling, purse seine and electrical fishing, experiments and pollution survey.

(4) Mara (Fisheries Research Vessel - F.R.V.): Used for gear testing in inshore waters, plaice egg and larval investigations. It is also used for bottom fauna, sprat, sandeel investigations and fish tagging operations.

(5) Goldseeker (F.R.V.): Mostly for shellfish - prawns, shrimps, crabs, lobsters and scallops.

(6) Navicula (F.R.V.): Involved in research programmed on energy flow, productivity and pollution at Loch Ewe and in Clyde estuary.

The fish resources investigation carried out by this Marine Laboratory concerned the studies of the abundance, composition, ecology and population dynamics of the chief stocks of demersal and pelagic fishes exploited by Scottish Fisheries on Northern North Sea, at the Faroes and off the Scottish North and West coasts. The data which the laboratory requires is often collected by the fish team of the Statistics Section, from the samples of the commercial catches landed at the Aberdeen Fish Market. Data are also collected from the research vessels sampling which included the stages in the life history of fish before exploitation.

There are six teams in the scientific and research branch. These are:-

(1) Fish Capture (team) Research:- This team carries out a trawling gear engineering performance experiment for pelagic and demersal fish. Also study fish reactivity to light, sound and electricity when fishing. The team tracks free-living fish in the sea by means of acoustic tape. A work shop for making fishing nets for the trawlers and seines is attached to this team.

(2) Fish Detection & Instrumentation:- The team uses sonar equipments and other instruments like underwater optics, oxygen sensing, and plankton sampling equipments, stereo camera and other photographic systems in fish detection.

(3) Environmental studies team:- Engaged in studies on effects of pollutants - like heavy metals on copepods and herring eggs and larvae.

The team also looks into productivity and plankton situation in the water, localisation of pollutants in fish tissues, nutrients and pollutant transfers.

(4) Others are Fish Parasites and Disease, Biochemistry and Physiology.

<u>Statistics team</u>: Mr. W. Hall is in charge. This section deals with the data collected from all other sections. The data so collected are analysed, and processed. The results of the fisheries situation in terms of population, exploitation rate etc. are made known either on monthly or yearly basis. The results of market sampling are used to build up the population of that particular spp. The data so collected from each fish at the market is first raised to boat total catch and further used to estimate the catch of the particular area. Operational vessels total about 80 trawlers, 20 seines and 5 light trawlers. These vessels are all Scottish and operate in northern North Sea and the Faroes. The sampling of major demersal stocks exploited by the Scottish vessels is a continuous exercise. This is being done with a view to monitoring any short term fluctuations. This will serve a useful purpose in forcasting prospects of these fisheries detecting and diagnosing the causes of longer term changes in the stocks. In short the findings of this laboratory places her on an advisory capacity to the Department of Agriculture and Fisheries, Scotland and to the International Fishery Commissions on national and internal fishery regulations.

<u>The Fish team</u>: Mr. A. Pirrie is in charge.

Team carries out fish market survey every morning. Fish samples are measured, scales and otoliths are taken for age determination. A box of fish out of many boxes of same spp. is sampled. Five otoliths are collected from same spp. of fish of same length. The length measurements, scale and otolith readings are later fed to statistics section for processing. Among the fish sampled are:-

Demersal - Haddock, Whiting, Cod, Saithe, Lemon Sole, Megrim, Halibut, Plaice, Redfish etc.

Pelagic - Herring, Sprat, Mackeral etc.

The salmon sampling result is sent directly to the Freshwater Fisheries Laboratory - Pitlochry. About 15 boats on the average berth at the fish market port-Aberdeen every morning and about 5,000 boxes of fish (both pelagic and demersal) are landed. This used to be up to 8000-10,000 boxes but of recent some boats started berthing at Peterhead further north of Aberdeen. Each box of fish weighs 6-10 stones on the average. A box of cod contains either 6 large cod or hundred small cod. A box of haddock (containing 200-215) has an equivalent weight as a box of cod. Aberdeen is not the only sampling place. Table 4 shows the other fish market sampling centres and the number of fish measured for the period of one year. There are fourteen fishing areas from where the fish are brought into the ports. The latest statistical figures of fish landed and processed in Scotland, by British vessels for 1974 as compared with that of 1973 are as shown in Tables 5 and 6 respectively.

Table 4 FISH MARKET SAMPLING

Numbers of Fish Measured for the Period 1st September 1971—31st August 1972

Port / Area	Cod Trawl	Cod Seine	Cod Light Trawl	Haddock Trawl	Haddock Seine	Haddock Light Trawl	Whiting Trawl	Whiting Seine	Whiting Light Trawl	Saithe Trawl	Saithe Seine	Saithe Light Trawl
Aberdeen/Peterhead												
North Sea	22,408	22,307	1,310	53,484	43,222	3,289	28,641	22,978	835	13,424	2,105	475
West Coast	884	35	1,808	2,454	—	•8,390	1,153	—	•7,990	212	—	—
Faroe	3,765	—	—	14,048	—	—	2,620	—	—	3,381	—	—
Iceland	1,014	—	—	2,864	—	—	68	—	—	—	—	—
White Sea Barents Sea, etc.	—	—	—	2,748	—	—	—	—	—	—	—	—
Fraserburgh												
North Sea	—	4,148	•2,321	—	19,922	•5,876	—	6,512	•2,556	—	—	—
Buckie/Lossiemouth												
North Sea	—	4,681	—	—	13,123	—	—	11,087	—	—	—	—
Newhaven/Granton												
North Sea	1,095	624	—	5,378	6,604	—	3,815	22,642	—	40	—	—
West Coast	—	—	—	—	—	—	189	—	—	—	—	—
Lerwick												
North Sea	—	3,896	643	—	15,512	1,410	—	12,352	1,168	—	66	125
Ayr												
West Coast	—	—	—	—	7,491	—	—	6,172	—	—	—	—
Clyde	—	274	•762	—	8,622	•2,350	—	10,084	8,649	—	—	—
West Coast Ports†												
West Coast	—	—	—	—	2,682	•1,419	—	1,253	•975	—	—	—
Clyde	—	—	•646	—	—	1,884	—	451	—	—	—	2,251

Port / Area	Hake Seine	Hake Light Trawl	Plaice Trawl	Plaice Seine	Plaice Light Trawl	Lemon Sole Trawl	Lemon Sole Seine	Lemon Sole Light Trawl	Megrim Trawl	Megrim Seine	Megrim Light Trawl
Aberdeen/Peterhead											
North Sea	—	—	27,729	10,638	372	33,713	6,372	—	7,622	1,419	224
West Coast	—	—	1,100	—	—	1,201	—	—	61	—	1,762
Faroe	—	—	2,407	—	—	15,211	—	—	132	—	—
Iceland	—	—	—	—	—	—	—	—	—	—	—
White Sea, Barents Sea, etc.	—	—	—	—	—	—	—	—	—	—	—
Fraserburgh											
North Sea	—	—	—	541	263	—	1,653	1,290	—	—	—
Buckie/Lossiemouth											
North Sea	—	—	—	11,997	—	—	—	—	—	—	—
Newhaven/Granton											
North Sea	—	—	—	—	—	—	—	—	—	—	—
West Coast	—	—	—	—	—	—	—	—	—	—	—
Lerwick											
North Sea	—	—	—	1,589	124	—	—	—	—	—	—
Ayr											
West Coast	—	—	—	—	—	—	—	—	—	—	—
Clyde	543	1,092	—	—	—	—	—	—	—	—	—
West Coast Ports†											
West Coast	—	—	—	69	—	—	—	103	—	29	—
Clyde	—	•195	—	—	—	—	—	—	—	—	—

•Includes Nephrops Trawl †Sampling at West Coast Ports by Aberdeen Team

(By the courtesy of Marine Lab. Aberdeen)

Table 5

Fish & Shellfish landed in Scotland by British Vessels

	Fish		Shellfish	
Year	Wt.(cwt.)	Value (£)	Wt. (cwt.)	Value (£) sterling
1974	9,016,629	£57,280,186	377,264	£6,781,617
1973	9,386,136	£53,059,874	473,053	£7,771,752
	Herring			
1974	2,547,594	£11,833,054		
1973	2,860,901	£8,629,017		
	Demersal			
1974	5,162,258	£43,333,794		
1973	5,165,620	£42,414,802		

(By the courtesy of Marine Lab.
- Aberdeen)

Table 6

Processed Fish - Herring

Year	Wt.(cwt.)	Value	Process Method
1974	658,447	£10,875,009	Canned, Kippered, pickle-
1973	695,987	£9,730,426	cured
1974	254,353	£8,024,614	Smoking and canning
1973	251,722	£6,437,791	

(By the courtesy of Marine Lab.
- Aberdeen)

In 1974, a total of 2,754 fishing vessels - 107 trawlers over 80 ft. and 2,647 other motor vessels - were in operation as against

2,689 vessels in 1973. The number of Scottish fishermen engaged were 9,571 (1,399 were only partially involved in fishing) in 1974 and 9,647 were employed in 1973 (Scottish Sea Fisheries Statistical tables 1974).

Trip 12

North East River Purification Board - Persley - Aberdeen 18-3-76

The North East River Purification Board, Aberdeen, was visited on 18/3/76. This is one of the newly formed River Purification Boards after reorganisation and regionalisation which reduced the number of Scottish River Purification Boards from nine to eight - (Highlands, Grampian, North East, Forth, Clyde, Tweed, Tay, Solway). The North East River Purification Board was formerly the Dee and Don River Purification Board. The board, presently is headed by Mr. Little and Mr. Johnstone is the deputy.

The Dee and Don River Purification Board (now the N.E.R.P. Board) set up under the Rivers (Prevention of Pollution)(Scotland) Act 1951, has the same organisational set up with the necessary sections and functions just like the other Scottish River Purification Board - Forth, already described. The major river in the area of the North East River Purification Board is the River Don. In October 1972 the average daily flow (a.d.f.) recorded on the River Don was only 67.5 million gallons daily (m.g.d.). This was as a result of the dry weather that persisted for long. In May 1973, 300 m.g.d., a.d.f. was recorded. During the period of heavy rainfall the a.d.f. could be as high as 480 m.g.d. for 130 days. A long term average flow of 420 m.g.d. has often been recorded. But the downwards trend (about 40% of the 420 m.g.d.) has been a cause for concern for any continuous discharge of effluent into the river will not be effectively diluted. The river has a turbid appearance and contains large masses of sludge as a result of industrial discharges.

Industrial Discharges to River Don: There are three main sources of discharge to River Don and are located upstream of Persley bridge.

(1) Ross Poultry Ltd.

Washings from the 27,000 birds slaughtered daily are roughly filtered and discharged directly into the River Don. Its effluent is noticeably coloured. This firm makes a discharge of 120,000 gals. (maximum discharge of 0.6 tons/day B.O.D.) with a peak strength in terms of B.O.D. of 1100 mg/l, (according to samples analysed at Persley Sewage Treatment Works).

(2) C. Davidson & Sons. Ltd., Mugie Moss Mill:

Paper and board makers. They produce about 130,000 tons of paper and boards yearly. The effluent treatment in this industry is by Krofta flotation and polydisk vacuum filter. The industry makes a discharge of about 5 million gals. with suspended solids to the River Don.

(3) Wiggin Teape: Stoneywood Mill:

Produces fine quality papers. Its main effluents go into Ames Crosta clariflocculator (sedimentation system) with an efficiency of 80% on suspended solids. The two paper mills were visited in the company of Mr. D. Cook - one of the N.E.R.P. Bd. officers. Most of the pollution affecting the RiverDon came from these paper mills as shown in Table 7 (attached). Stoneywood seems to have improved by almost 80% when compared with what it used to discharge in 1957.

Table 7. POLLUTION LOAD ON LOWER DON

AS ASSESSED AT MAY 1973.

Source	Description	Daily Quantity gallons (population)	Assumed Strength- mg/l BOD	SS	Pollution Load Tons/day BOD	SS	Remarks
Dyce Village	Treated Sewage	150,000 (3,000)	20	30	0·01	0·02	Persley STW
Stoneywood, Bankhead & Bucksburn	"	650,000 (13,000)	20	30	0·06	0·09	"
Balgownie & Bridge of Don	Partially treated sewage mostly	250,000 (5,000)	150	150	0·17	0·17	Septic tanks
Lawson's factory	-	Nil	-	-	-	-	Sea outfall
Stoneywood Mills	Partially treated	6,000,000*	80*	150	2·15	4·03	Mills say 2·4 tons SS
Mugiemoss Mills	"	5,000,000*	100*	105	2·24	2·35	
Ross Poultry Plant	Untreated	120,000*	1,100*	1,100	0·59	0·59	
Totals		12,170,000			5·22	7·25	

* Assumed figures

(from Scottish River Purification Advisory Committee, Report on Pollution in the Lower Don, 1973.)

The Persley Sewage Treatment Works:

This sewage treatment works was set up following the recommendation of the Scottish River Purification Advisory Committee and it is under the control of the county council in the area of authority of the N.E.R.P. Bd. The sewage work handles domestic sewage from Dyce, Balgowrie and Bridge of Don and also sewage from Stoneywood, Bankhead and Bucksburn. The Ross Poultry also discharges its well screened effluent into the Persley Sewage Treatment Works for further treatment. All the treated discharge according to the Royal Commission standard (20 mg/l. B.O.D. and 30 mg/l. S.S.) are made into the River Don. Since this work was set up in 1974, a significant improvement of the water quality of the River Don has been made.

The sewage work is not large enough to take up effluents from other sources so the operating paper mills have their own treatment works before a discharge is made into the River Don. The Persley works has a screening section followed by primary sludge settlement tanks. These settled effluents are treated by activated sludge system, in the biological activation unit. The attached illustration, Plate 11, shows part of the activated sludge system in operation.

Apart from the pollution problem, the N.E.R.P.Bd. is yet faced with another task. It is the problem of water abstraction from the River Don by surrounding industries.

Water Requirement by Respective Industries

Industry	Water Requirement
Paper	32,000 gal/ton
Broiler	5 gals or more/3 lb.(bird)
Whisky	70,000 gal/100 gal whisky

PLATE 11. Some of the aerators of the activated sludge system in operation at the Persley Sewage Treatment Works - Aberdeen.

Attempts are being made by the David Muggiemoss Mill to recycle and clarify water for use, thus reducing fresh intake. If one imagines the output of the two paper industries and the Poultry firm, the amount of water required will be tremendous and then return which is not wholly unpolluted, to the River Don is capable of having adverse effect on the aquatic life. Upstream i.e. at Parkhill, the result of water analysis before the points of discharge was good. But the situation deteriorated south as the fibre laden effluent from Muggiemoss paper mill and the offal, feather and blood from Ross Poultry Unit join. All these together with the water abstraction, lowered the dissolved oxygen level thus making it intolerable for salmon and trout. Although no official statistics to confirm the effect of pollution on Fisheries, there seems to have been a decline for over ten years. The result of decline is still attributed to pollution nevertheless, for by 1972 mass death of smolts was reported. In 1973 also there was a report of gaping adult salmon in an attempt to escape the deadly mess of paper fibres, which caused the deoxygenation of the water. Biological survey work done by Dr. D.H. Mills in 1967 and 1973 confirmed the poor fisheries condition in the lower part of the River Don.

It is hoped that with the setting up of Persley Sewage Treatment Works, pollution on the Don, which is a salmon river, will be very minimal. There is also a management attempt by Stoneywood paper mills to reduce total effluent volume and request has already been made to Persley to receive the coating discharge from Stoneywood paper mill effluent for further treatment.

The Glendronach (Teacher's Whisky) Distilleries at Forgue

This is one of the distilleries for Teacher's Whisky. This distillery is in Forgue which is 36 miles north of Aberdeen. The distillery which is within the jurisdiction of N.E.R.P.Bd. was visited in the company of Messrs. Ian Lambert and D. Cook - both staff of the Purification Board. They are charged with specific areas of the Board's zone, to see that effluents are properly treated before discharge is made into river and burns.

The Glendronach Distilleries formerly had only a sedimentation lagoon but now operate a biological treatment unit, involving chemical precipitation, primary settlement and trickling filtration. The lagooning which was the only system employed before led to heavy bloom of algae at the point of discharge in the burn. The surface of the burn was equally covered with algae bloom. But since the introduction of the new system of sewage treatment, the adverse effect of the discharge to the burn has been averted.

Trip 13

Kenmure Fisheries - New Galloway (Scotland). 21 - 6 - 76.

This is a commercial enterprise involving a rainbow trout farm rearing unit and fish processing centre. The fishfarm is owned by Mr. G. H. Gordon who is presently the chairman of the British Trout and Salmon Marketing Association. The aim of this Association is to assist table trout and salmon farmers in Britain to produce and market their products more efficiently by providing services including market intelligence, advice and publicity.

All the ponds of the farm have black polythene lining on the bottom and edge to avoid weed problem. Gravels and rubbles form the bed of the ponds. Clean water is continuously fed to the ponds by a generator which pumps water from Loch Ken. The outflowing water from the ponds is collected into a settlement pond before discharge into the River Ken. Each water inlet and outlet of a pond can be controlled without affecting the water supply to the other ponds. The ponds which are many are designated for different sizes, age and quality (for breeding purposes) of fish. As the fish advance in size, age etc. they are moved from smaller to bigger ponds. Each pond has a demand feeder so the fish take their feed at will. The feeding activity being governed by water temperature. Feeding the fish in farm takes about 120 tons of feed yearly. The cost of fry feed, which is more of protein about 50%, of which at least 75% is animal protein, being more expensive than growing or finishing pellets for the adult fish.

One million rainbow trout eggs are imported annually from Denmark in accordance with strict import regulations (see chapter 4.3.5 of thesis). These eggs are hatched in the farm's hatchery and planted out to the farm ponds. The average growing period is about 18 months by which time they have attained a weight of about 8ozs each.

Harvesting of the fish for the market is by draining of the ponds afterwhich they are cleaned and left dry for some time. Weed control on the edge of the ponds is by cutting with scythes and raking of dislodged plants.

Predator (for an example gulls) control is by installation of overhead wires horizontally to prevent the birds from diving for fish.

The control of gulls help to prevent the spread of parasites such as eye flukes. The viral disease, IPN, has also been noted in this farm. Because of this infection, fish from the farm are not allowed for stocking public waters for the purpose of angling.

There are two brood stock ponds which serve for egg production (in time of emergency) if financial and legal limitations place an embargo on fish egg importation from Denmark.

Fish Processing Factory:-

This factory is jointly supplied with rainbow trout by Invicta Trout Ltd; Torhouse Fisheries Ltd. and Kenmure Fisheries Ltd. The factory is sited at Kenmure Fisheries premises and annually Invicta supplies 70 tons, Torhouse 70 tons and Kenmure about 120 tons of rainbow trout for processing.

The factory guts the fish and grades them into sizes. Depending on requirement, the fish are iced or smoked dry before being packed and dispatched to marketing centres. Light float boxes instead of wooden boxes are used for packing the fish to the market. Each box weight is estimated at about 5lbs irrespective of the size of the fish in it.

Trip 14.

Joseph Johnston and Sons Ltd; Montrose, Scotland. 25 - 6 - 76.

This is one of the largest commercial salmon fisheries in Scotland. The managing director, Mr J. Stansfield is the chairman of the North Esk Fishery Board.

The firm has about 15 netting stations on the coast. These stretch between Aberdeen to Montrose and further south. Each netting station has an engine powered boat with a team of 3-4 fishermen who at scheduled intervals fish out the salmon caught in the nets. Bag nets used on rocky beds are set about one-third to half a mile from the coast and in each station there are about 10 bag nets, which are spread out some distance between each other on the coast.

In the company of the fishermen we went out in the boat to harvest the salmon caught in the nets. Skill is required in manoeuvering the boat and lifting the bag of the net to remove the trapped salmon.

On the sandy coast, stake nets are set for salmon and sea trout. The fish are directed by the leader into the pockets of the net. The leader which is a curtain of netting is a part of the net stretching out to the sea at right angles to the coast. The fish shoal moving along the coast, on striking the leader, are directed into the pocket of the net. The stake nets are gigantic and in harvesting their catch, fishermen use hand nets mounted on long poles and move on the rope from one pocket to another.

The harvested fish are graded into two classes(first & second) in the firm's processing centre. The first class fish are those that bear no marks of injury and show signs of freshness. The second class fish are the ones that have net and predator wounds or have lost parts of their body. Also diseased and long dead fish tending to show signs of putrefaction are regarded as second class fish. Salmon remains left by predators such as the grey seal were on display.

The firm confirmed that they lose a substantial quantity of fish every year due to depredation on salmon by seals in particular (see chapter 3.5. of thesis). The fish are weighed after grading and are either iced or smoked according to the choice of the fishmonger customers. They are then packed in wooden boxes and ready for despatch.

The firm also operates a net and coble fishery in the River North Esk at Morphie Dyke and owns a stretch of river which they let to anglers.

For the purpose of curing and preserving the fish, the firm operates iceblock making machines, freezing and smoking units. The ice-chips are packed with the fish in the box to keep them fresh while in transit to marketing centres. Alternatively the fish are frozen to a temperature below -10°C. In this state the fish stay long without becoming rancid.

Two types of smoking are used by the firm:-

1. Hot smoking: The temperature is about 140°C in the smoking kiln for only 6hrs. or less.

2. Cold smoking: The temperature is not as high as in hot smoking and the fish stay longer (about 8-10hrs.) in the kiln. According to the firm, their record of salmon catch has shown a decrease on what it used to be. This is the general complaint expressed by other commercial salmon fishing companies and is attributed to the Northumbrian drift netting and partial action of salmon predators.

Tagging station.

For research purposes, a tagging station near Hillside at Montrose has been built by the Fresh-water Fisheries Laboratory, Pitlochry. The essence of this is to record salmon and sea-trout parr and smolts migrating to the sea and to find out how many of these return to spawn. A small arm of the North Esk River has a trapping system installed in it. Smolts following the water flow to the sea are cornered into a deep cement tank whose inflow is controlled by electrically operated sluices. The water in the tank is emptied at intervals to a level through a sieved outflow into the stream. This allows fish to be removed with hand nets after the mechanically operated sluices have reduced the water level. The juvenile fish are anaesthetised with M.S.222, tagged, measured, scale samples taken and released in the North Esk River from where they go to sea. The tagging exercise is of considerable interest to the Freshwater Fisheries Laboratory, Pitlochry. Records of tagging revealed in 1976 a poor salmon smolt migration as against the previous years. Only about 6000 smolts were tagged in 1976 as against the yearly average of about 12000 in the past. This poor recruitment has evidently reflected the small number of adult salmon that found their way to the spawning grounds.

Smolt Rearing Station:

Continuing efforts are being made by Joseph Johnston and Sons Ltd, to increase salmon stock through artificial recruitment. To this end, brood salmon stocks are kept in tanks. They are spawned and the eggs hatched in the firm's hatchery. The juvenile fish are reared to the smolt stage before being released to the sea or taken to the Northwest Sutherland where they are reared in sea cages to the adult stage. The rearing unit tanks, shown in plate 6 which are sited at the estuary of the N.Esk are fed with freshwater by gravitation. Because of the high temperature during the summer time (when the visit was made) some of the smolts and parr were found dead despite the continuous inflow of freshwater into the tanks.